ISSN 0255—5581

# TAIWAN SUGAR RESEARCH INSTITUTE

# ANNUAL REPORT

# 1992—1993

INTERNATIONAL MYCOLOGICAL INSTITUTE

CAB INTERNATIONAL
00109583

With the Compliments of the
Director

Wang, Chwan-chau

Chwan-Chau Wang, Ph.D.

TAIWAN SUGAR RESEARCH INSTITUTE
54 SHENG CHAN ROAD, TAINAN, TAIWAN 701
REPUBLIC OF CHINA

INTERNATIONAL
MYCOLOGICAL INSTITUTE
LIBRARY
20 JUL 1994

Digitized by the Internet Archive
in 2025

https://archive.org/details/taiwan-sugar-research-institute-annual-report_1882-1993

# TAIWAN SUGAR RESEARCH INSTITUTE
# ANNUAL REPORT
# 1992–1993

54 SHENG CHAN ROAD
TAINAN, TAIWAN
REPUBLIC OF CHINA

# CONTENTS


FOREWORD ..... 1
RESEARCH AND DEVELOPMENT ..... 3

- Sugarcane Breeding ..... 3
- Agronomy ..... 9
- Horticulture ..... 16
- Plant Pathology ..... 28
- Entomology ..... 32
- Sugar Technology ..... 36
- Biotechnology ..... 38

RESEARCH PROJECTS IN PROGRESS ..... 43
TECHNICAL SERVICES ..... 45
PUBLICATIONS ..... 47
APPENDIX ..... 51

- Seminars ..... 51
- Scientists Sent Abroad for Advanced Study, Investigation, or Participation in International Symposia ..... 52
- Foreign Visitors ..... 52
- Personnel ..... 53

# Foreword

The Taiwan Sugar Corporation (TSC) has consistently played an important role in the development of the rural economy of Taiwan. But in recent years, unexpected changes in the socio-economic environment require that this government-run enterprise broaden its outlook and diversify its production into many areas other than sugar and its by-products. Also, appropriate plans and strategies are being made and put into operation to promote industrial growth and to improve the quality of life, such as using the large area of TSC lands to meet the needs of establishing industrial zones, large shopping centers, and resorts. In order to substantially support the goals and profitability of TSC, research works at the Taiwan Sugar Research Institute (TSRI) focus on practical applications with attention to advancing the diversification of the sugar industry in Taiwan.

Many significant research achievements have been made at TSRI in 1992-1993. A new sugarcane variety well adapted to sandy soil and suited to mechanical harvesting, ROC17, was released this year. Its sugar content was similar to that of F160, but it was superior to F160 in both cane and sugar yields. The duration of bagasse composting was shortened by four or more months using a forced-aeration system. An automatic system to control greenhouse conditions for *Phalaenopsis* cultivation was developed, and the performance of a mechanism of a transportable bench system designed to operate between the greenhouse and working stations were tested at TSRI. At the international orchid shows last year many of the new hybrids bred by this institute won awards and prizes. A technique for micropropagation of disease-indexed Badila cane was developed. The technique can be used for eradication of systematic disease of sugarcane and for the generation of a great number of plantlets in a short period of time. Research on synthetic sex pheromone compounds produced an effective bait to the sugarcane gray borer. A computerized control system for the multiple-effect evaporator of sugar mills was developed and constructed with the GENESIS control software package. Improvements on stabilities of syrup Brix and liquid level in the evaporator were primarily achieved. A strain of alkalophilic *Bacillus* sp., No. 35, for producing CGTase was successfully isolated. With the same CGTase, a 56% coupling sugar conversion was obtained after a reaction time of 24 hours. For the disposal of surplus bagasse from sugar mills, research on producing both bagasse board and gypsum flake board with bagasse instead of waste paper fiber showed great potential for commercial production.

It is our hope that the research achievements as described in this Annual Report 1992-1993 will contribute to the enhancement of our sugar industry.

Chwan-Chau Wang, Ph. D.
Director

# Research and Development

## *Sugarcane Breeding*

### The Release of the New Variety ROC17

A new variety, ROC17, was released in 1993; it was derived from the cross 75-299 ×F162 (Fig. 1). ROC17 was similar to F160 in sugar content and maturity (Fig. 2), but ROC17 was especially well adapted to sandy soil under irrigation. Data from regional trials on sandy soil indicated that ROC17 was superior to F160 in yield per hectare of both sugar and cane in the plant cane and in the ratoon crops. This variety was generally erect and was suited to mechanical harvesting.

ROC17 was highly resistant to downy mildew, leaf blight, mosaic virus, and rust; and moderately resistant to smut and leaf scorch. Based on the results of dipping in a freshly isolated bacterial suspension, it appeared susceptible to leaf scald. This variety was highly resistant to sugarcane woolly aphid and was tolerant to the herbicides currently used in sugarcane fields for weed control. (Y. S. Chang)

Fig. 1. The newly released variety ROC17.

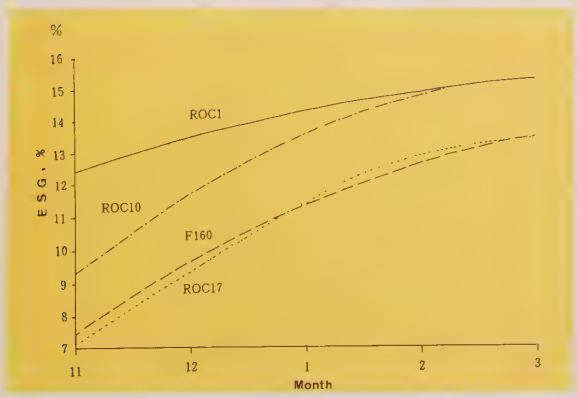



Fig. 2. Monthly change in sugar content of ROC 17 during maturation as compared to changes in content of ROC1, ROC10, and F160. Data represent the average from five successive crop years at Wantan Sugarcane Breeding Station.

### Sugarcane Variety Census for the 1993-94 Crop Year in Taiwan

The total land area in Taiwan occupied by sugarcane grown for seed or for milling was 60,297.90 hectares in 1993-94. The 1993 census indicated that there were ten varieties that occupied 1% or more of the total hectarage in the 1993-94 crop year. The most widely grown variety was ROC10, planted on 50.73% of the total sugarcane hectarage (Table 1). ROC10 has been the leading variety since the 1987-88 crop year. The second most widely grown variety was ROC1. This variety was grown on 17.33% of the total hectarage, 4.56% point less than in the 1992 census. The third leading variety was ROC9, which occupied 10.56% of the total hectarage, an increase of 0.82% point over the 1992-93 hectarage. The fourth most popular variety was F160, reported on 5.71% of the total hectarage. Its share of the hectarage has not changed since the 1992-1993 crop year. The percentage shares of both ROC7 and ROC5 have decreased by approximately 0.4% point of the total hectarage. Compared to the 1992 census ROC13, ROC15, and ROC16 have increased in total hectarage by 0.48%, 2.03%, and 1.00% points, respectively. ROC11 de-

**Table 1. Top 11 sugarcane varieties in the 1993–94 crop year**

| Variety | 1993–94 | | 1992–93 | |
|---|---|---|---|---|
| | Hectares | % | Hectares | % |
| ROC10 | 36,542.97 | 50.73 | 30,106.42 | 48.51 |
| ROC1 | 10,435.13 | 17.33 | 13,582.41 | 21.89 |
| ROC9 | 6,358.11 | 10.56 | 6,044.39 | 9.74 |
| F160 | 3,436.51 | 5.71 | 3,564.94 | 5.74 |
| ROC7 | 3,092.26 | 5.14 | 3,419.24 | 5.51 |
| ROC5 | 1,525.29 | 2.53 | 1,818.33 | 2.93 |
| ROC15 | 1,390.75 | 2.31 | 170.69 | 0.28 |
| ROC13 | 770.07 | 1.28 | 495.87 | 0.80 |
| ROC16 | 611.53 | 1.02 | 12.02 | 0.02 |
| ROC11 | 602.89 | 1.00 | 1,295.26 | 2.09 |
| F177 | 362.77 | 0.60 | 392.15 | 0.63 |
| Others | 1,078.72 | 1.79 | 1,157.90 | 1.86 |
| Total | 60,297.90 | 100.00 | 62,059.62 | 100.00 |

clined by 1.09% point of the total hectarage due to susceptibility to leaf scald. The variety F177 remained similar in hectarage to the 1992 census. (Y. S. Chang)

## Sugarcane Crossing and Seedling Raising

Flooding due to heavy rain in the spring of 1992 and drought the following summer inhibited sugarcane growth in the 1992–1993 crop year, but did not affect the timing of flowering. Sugarcane crossing began on 18 November 1992 and ended on 13 January 1993. Of the 423 parents used (representing 142 exotic varieties, 38 domestic varieties and 243 clones), 281 parents (66.4%) flowered in the Hengchun nursery.

In addition, 63 parents were subjected to 12 hrs 15 min daylength photoperiodic treatments at Wantan Sugarcane Breeding Station in order to regulate and synchronize flowering. The late or poorly flowering parents began treatment on 12 July or 27 July; while the early or profusely flowering parents began treatment on 13 August. Of the 63 parents, 81% (51 parents) flowered during the crossing season.

Tasseling stalks of parents were collected from the Hengchun nursery and transported to the crossing house at the Wantan station twice a week. The parents most extensively used in crossing were 69–463, ROC10, 74–575, ROC5, CP58–48, ROC12, and ROC1. Seven hundred and seven cross combinations were made. A total of 1613 tassels of fuzz were harvested; 801 were prepared by marcotting and 812 by the modified $SO_2$ solution method (Table 2).

Within six weeks beginning in late December, 991 tassels of fuzz, including 958 tassels of deep-freeze stored fuzz and 33 tassels of fresh fuzz, were sown in the greenhouse. The tassels prepared by marcotting and $SO_2$ solution methods averaged 403 and 207 seedlings per tassel, respectively. A total of 298,887 seedlings were planted in the field at six regional selection stations between late April and late May of 1993 (Table 3). (Department of Plant Breeding)

**Table 2. Sugarcane crosses completed in 1992–93**

| Classification of crosses | No. of combinations | No. of tassels obtained | | |
|---|---|---|---|---|
| | | Marcotting | $SO_2$ solution | Total |
| Commercial cross | 3 | 5 | 6 | 11 |
| Proven cross | 149 | 215 | 214 | 429 |
| Test cross | 461 | 464 | 476 | 940 |
| Nobilization cross | 32 | 24 | 33 | 57 |
| Consignment cross | 62 | 93 | 83 | 176 |
| Total | 707 | 801 | 812 | 1,613 |

**Table 3. Number of seedlings raised in 1993**

| Regional selection station | No. of combinations | No. of tassels sown | No. of seedlings planted |
|---|---|---|---|
| Tainan | 183 | 228 | 97,155 |
| Wantan | 200 | 301 | 70,724 |
| Huwei | 99 | 184 | 32,198 |
| Hsinying | 39 | 60 | 28,947 |
| Changlung | 79 | 93 | 33,080 |
| Hualien | 62 | 125 | 36,783 |
| Total | | 991 | 298,887 |

## Clonal Selection

In the 1992–93 crop year, a total of 132, 345, 1,094, and 6,429 clones were selected from Series 89, 90, 91, and 92, respectively, for T1, T2, and T3 tests (Table 4). In addition, 16 clones from Series 90 were selected for a T3 trial; and 86 clones from Series 87, 88, and 89 were selected for a regional adaption trial (T4).

Based on monthly analysis of mean sugar content between October and the following April during three crop years, ROC16 was found to mature earlier than

**Table 4. Number of clones chosen for each selection stage at seven regional stations during 1992–1993**

| Regional selection station | No. of clones selected | | | |
|---|---|---|---|---|
| | Series 92 (T1) | Series 91 (T2) | Series 90 (T2 & T3) | Series 89 (T2 & T3) |
| Tainan | 1,826 | 221 | 40 | 26 |
| Wantan | 1,263 | 263 | 88 | 30 |
| Houli | –* | –* | 35 | 1 |
| Huwei | 441 | 145 | 48 | 15 |
| Hsinying | 650 | 185 | 63 | 30 |
| Changlung | 1,028 | 121 | 37 | 9 |
| Hualien | 1,221 | 159 | 34 | 21 |
| Total | 6,429 | 1,094 | 345 | 132 |
| Selection rate (%) | 1.74 | 13.96 | 27.69 | 50 |

* Suspended.

**Table 5. Monthly analysis of sugar content for ROC1, ROC10, and ROC16 during the past three crop years**

| Variety | Crop year | Sugar content (%) | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Oct. 15 | Nov. 5 | Dec. 5 | Jan. 5 | Feb. 5 | Mar. 5 | Apr. 5. |
| ROC1 | 1990–1991 | 12.21 | 12.90 | 14.37 | 14.88 | 15.11 | 14.95 | 15.00 |
| | 1991–1992 | 11.73 | 12.87 | 13.56 | 14.59 | 14.54 | 14.61 | 13.75 |
| | 1992–1993 | 12.27 | 13.06 | 14.10 | 14.58 | 14.32 | 14.26 | 13.93 |
| ROC10 | 1990–1991 | 10.03 | 11.44 | 13.12 | 14.16 | 14.61 | 15.12 | 15.52 |
| | 1991–1992 | 9.58 | 11.10 | 13.26 | 14.23 | 14.48 | 14.59 | 14.46 |
| | 1992–1993 | 9.94 | 11.39 | 12.99 | 13.67 | 14.26 | 14.64 | 14.81 |
| ROC16 | 1990–1991 | 12.34 | 13.45 | 14.23 | 14.90 | 14.83 | 15.72 | 15.80 |
| | 1991–1992 | 11.75 | 12.52 | 13.84 | 14.28 | 14.16 | 14.29 | 14.47 |
| | 1992–1993 | 11.55 | 12.97 | 13.25 | 14.53 | 14.26 | 14.36 | 15.62 |
| Mean | 1990–1991 | 11.53 | 12.60 | 13.91 | 14.65 | 14.85 | 15.26 | 15.44 |
| | 1991–1992 | 11.02 | 12.16 | 13.55 | 14.37 | 14.39 | 14.50 | 14.23 |
| | 1992–1993 | 11.25 | 12.47 | 13.45 | 14.26 | 14.28 | 14.42 | 14.79 |

ROC10 and similar to ROC1 (Table 5). (Department of Plant Breeding)

## Regional Test

A total of 110 clones at T4 stage, 54 clones at T5 stage, and 4 clones at T6 stage were tested in 58 sets of regional trials conducted in the 1992–93 crop year (Table 6). The results showed that the clones 81–2543, 82–2825, 83–9490 and 85–6409 performed especially well.

Clone 81–2543 is specifically adapted to sandy soils and was released as ROC17 on 18 June 1993. Clone 82–2825 performed better than the current leading variety, ROC10, at the regional trial. Clone 83–9490, showing superior cane and sugar yields compared to ROC9, has proven to be well adapted to the gravel soil of eastern Taiwan. Clone 85–6409, which matures very early and has a sucrose content higher than ROC1, showed high tonnage in the red highland soil of middle Taiwan. (Department of Plant Breeding)

**Table 6. Number of clones at the regional trials conducted in 1992–1993 crop year**

| Stage | Number of clones | | | No. of trials |
|---|---|---|---|---|
| | Plant cane | First ratoon | Total* | |
| T4 | 110 | – | 110 | 15 |
| T5 | 35 | 28 | 54 | 30 |
| T6 | 2 | 2 | 4 | 13 |
| Total | 147 | 30 | 168 | 58 |

* Duplicates are excluded.

## Assessment of Genetic Merits for Parent Varieties

The genetic merits of 18 female and 9 male parents were assessed using the poly-cross test. Six testers, 74–575, CP58–48, F175, ROC7, ROC10, and ROC12, with equivalent pollen quantity and fertility were used as pollen donors for evaluating the female parents. Five female parents were

randomly chosen as ovule donors for assessing the male parents. Two parameters, family mean and BLUP (Best linear unbiased predictor), were employed in this study. A random sample of 45 offspring for each polycross were surveyed for Brix, stalk length, stalk diameter, stalk number, pith quality, tube quality, and rusts. The results of the assessment are shown in Tables 7 and 8. (Y. S. Chang)

**Table 7. The genetic merits of 18 female parents**

| Female parent | Brix | Stalk no. | Stalk diameter | Stalk length | Pith quality | Tube quality | Common rust | Orange rust |
|---|---|---|---|---|---|---|---|---|
| BO14 | | ◎ | | ◎ | △ | | ○ | |
| CP63-306 | ◎ | ◎ | | △ | ○ | | ○ | ◎ |
| CP67-412 | ◎ | ○ | | △ | △ | ○ | | |
| CP70-321 | ◎ | ◎ | | △ | ○ | | | ◎ |
| CP72-370 | ◎ | | | ○ | △ | | ○ | |
| CP72-1210 | ○ | | ○ | △ | ○ | ○ | ○ | |
| F69 | ◎ | | △ | | △ | ○ | | |
| F146 | | ◎ | △ | | ◎ | ○ | | |
| ROC1 | ◎ | | △ | △ | ◎ | ○ | ○ | |
| ROC16 | ○ | | △ | △ | ○ | △ | ○ | ○ |
| 66-531 | | ○ | ◎ | ○ | △ | △ | | |
| 68-756 | | | | ○ | ○ | | ○ | |
| 71-296 | △ | | ○ | △ | ○ | ◎ | | |
| 76-12 | △ | ○ | ◎ | ○ | ◎ | △ | | ○ |
| 77-73 | △ | | ◎ | | △ | △ | | |
| 82-3084 | ○ | △ | | ◎ | ○ | △ | | |
| 82-9264 | ○ | ○ | ○ | | ○ | ○ | | ○ |
| 83-9501 | | ○ | ◎ | △ | ◎ | △ | ○ | ○ |

◎=excellent ○=good △=acceptable

**Table 8. Genetic merits of nine male parents**

| Male parent | Brix | Stalk no. | Stalk diameter | Stalk length | Pith quality | Tube quality | Common rust | Orange rust |
|---|---|---|---|---|---|---|---|---|
| 48-21 | ○ | ○ | | ◎ | ○ | ○ | ○ | ○ |
| 58-2382 | | | | | | | ○ | ○ |
| 58-2566 | ○ | | | ○ | ○ | ○ | ○ | |
| 64-1152 | | | | | ◎ | | | |
| 65-28 | ○ | ◎ | | ○ | ◎ | | | |
| 69-463 | ◎ | | | | ◎ | | △ | ○ |
| 70-2735 | ◎ | ○ | ○ | | ◎ | | ○ | |
| CP58-48 | ○ | ○ | ○ | ○ | | | △ | |
| ROC10 | ○ | ○ | ○ | ○ | ◎ | ◎ | ○ | |

◎=excellent ○=good △=acceptable

## Repeated Plant Regeneration from Sugarcane Protoplasts

In March 1993, plants were successfully regenerated a second time from sugarcane protoplasts. First, a cell suspension culture was established from a leaf-derived 4-month-old callus of cv. F177. After 2 to 3 months, cell-aggregates were treated with an enzyme mixture to release protoplasts. The protoplasts were purified and then embedded in a 1.2% agarose block containing PRM−7 medium (MS salts + K8P organic supplements). The block was cut into four pieces which were cocultured in a 6-cm dish with 5 ml of a nurse culture consisting of rapidly growing cells. The nurse cell culture was replaced every week to maintain proper cell density and solute potential. The protoplasts (P) formed callus tissue within one month. The P-callus was divided into two portions (1.5 cm diameter) and inoculated onto a solid MS medium where they were surrounded by a 0.8-cm thick wall of callus having many newly differentiated green buds (2−5 mm in height). It is thought that the peripheral green buds secrete an unknown differentiating factor which diffuses into the enclosed P-calli and triggers meristematic growth. After 30 days, the treated P-calli were transferred onto a differentiation medium where many green buds formed within one month. However, the small green buds (only 1 mm in height) were too weak to transfer directly into culture medium. Instead, the regenerated green buds were inoculated onto a cell-pad consisting of concentrated, rapidly growing suspension cells. The rapid growth characteristic of the suspension cells stimulated the green buds to grow normally (Fig. 3). One month later, they grew into plantlets. They were raised to adult plants according to our laboratory procedures. (M. C. Liu)

Fig. 3. The newly differentiated green buds from sugarcane protoplasts are grown into plantlets with the assistance of a cell-aggregate pad.

## Breeding of Gladiolus

More than 20 imported commercial cultivars of gladiolus were used as parents for breeding varieties tolerant of high temperatures and resistant to major viruses. A total of 102 cross combinations, 299 crossing spikes, and 17,370 F1 progenies were obtained in the 1992−1993 crop year. The cormlet size of F1 seedlings were 1.5

Fig. 4. Segregation for corm peel color in the first clonal generation (Applause x White Prosperity).

times larger when the hybrid seeds were sown directly in the field rather than cultured in trays first. This year the F1 seedling cormlets were harvested three weeks earlier than last year.

At the first clonal generation of testing stage (T1), a total of 6,744 clones were selected; the average selection rate was 34.7%. Within 14 months after the hybrid seeds were sown, 3.2% of the first generation clones bloomed. Cross combinations of Applause × White Prosperity, Applause × Traveler, and Priscilia × White Prosperity resulted in a larger corm size and a higher blooming rate. The first clonal progenies segregated widely for flowering time, flower color, flower size, corm peel color (Fig. 4), and numbers of young cormlets. Schemes for handling and selecting gladiolus progenies are being developed. (Y. T. Chen and C. C. Lo)

## *Agronomy*

### Climate and Sugarcane Growth

In the sugarcane growing region of Taiwan, 1992 was a year of unusual rainfall distribution. Excess rainfall fell in January-April, surpassing rainfall records for the past 58 years. Then almost no rain fell for one and a half months, beginning in June, which led to a serious water deficit during the fast growing stage. These flood and drought conditions were unfavourable for sugarcane growth.

In addition to flood and drought, typhoons also severely restricted cane production. Three typhoons passed through the Taiwan area: Polly on August 30, Omar on September 4, and Ted on September 21. They adversely affected the growth of all planting cane, though damage to the spring and ratoon canes was more severe than that to the autumn planting cane. Such severe weather depressed sugarcane growth and resulted in a 10% reduction in cane yield compared to last year's crops.

From October 1992 until the end of the year the weather was cool and dry. A large daily range of temperatures and plenty of sunshine contributed to the beneficial accumulation of sucrose in the sugarcane during the early cane harvest stage. The sugar content of the 1992–93 crop in the milling period was higher than that of the 1991–92 crop. (R. T. Tang and K. Y. Jian)

### Sugarcane Varietal Response to Herbicides

New sugarcane varieties usually have to pass herbicide tolerance tests before they can be released. In the 1992–93 crop year, the test of 85–6409, a T6 stage clone, was undertaken. The clone was shown to be highly tolerant to the preemergence herbicides atrazine, at the dosage of 1.5 kg active ingredient (ai)/ha, and diuron, at the dosage of 1.6 kg ai/ha. No herbicide injury occurred when ametryn, a postemergence herbicide, was sprayed on 85–6409 seedlings at either 1 or 2 months of age at the dosages of 1.6, 2.4 and 3.2 kg ai/ha. Seedling growth was slightly retarded by ametryn, but by 6 months after planting no significant differences among herbicide treatments and the handweeding check were observed. Another greenhouse trial of ametryn tolerance of 10 recently released cultivars and T6 stage clones was conducted in August 1992. The results agreed with those data obtained from previous field trials. Cultivars 82–2825 and 83–9490 were found to be especially susceptible to ametryn. Care should be taken when applying ametryn to these cultivars. (M. C. Liu and L. T. Twu)

### Drought Resistance Levels of Sugarcane Varieties ROC12, ROC13, ROC15, and ROC16

A rating system which contains three major components, drought tolerance, soil water depletion pattern, and root distribution pattern, has been established for determining the levels of drought resistance in sugarcane varieties. The sugarcane varieties ROC12, ROC13, ROC15, and ROC16 were rated for drought resistance. The varieties ROC1, ROC7, ROC9, ROC10, which have drought resistance indices of 19, 10, 19, and 8, respectively, were used as checks. Drought tolerance was determined by measuring the ability of sugarcane roots to survive water deficits induced with polyethelene glycol (PEG)−6000. The results indicated that ROC12 and ROC15 were relatively drought tolerant, like ROC7, and that ROC13 and ROC16 were relatively intolerant to drought, like ROC9 (Table 9). The soil water depletion pattern was measured by the neutron probe moisture meter. ROC16 had the same pattern as ROC1, while ROC12 and ROC13 had patterns similar to ROC10. The soil water depletion profile of ROC15 was more shallow than the other varieties (Fig. 5). The root distribution patterns were investigated in the field. ROC12 and ROC13 had shallow root distributions like those of ROC7 and ROC10, while ROC15 and ROC16 had deep root development like those of ROC1 and ROC9. The root density at 0−30 cm in the soil profile was high in varieties ROC10 and ROC13, but low in varieties ROC12 and ROC16 (Table 10). With the above data, the drought resistance levels of varieties ROC12, ROC13, ROC15, and ROC16 can be estimated by means of the rating system. The drought resistance indices shown in Table 11 indicate the level of drought resistance. A higher value indicates a higher drought resistance. The drought resistance indices of the experimental varieties were all intermediate to those of the checked varieties. Of the experimental varieties ROC16 was found to be the most drought resistant while ROC13 was the least. The order of the ability to resist drought was as follows: ROC1 and ROC9 (19), ROC16 (18), ROC15 (16), ROC12 (13), ROC13 (11), ROC7 (10) and ROC10 (8). (Y. S. Sheu and L. Kong)

**Table 9. Effect of different water potentials on sugarcane root development**

| Variety | Root, fresh weight (g) | | | |
|---|---|---|---|---|
| | Ck. | −1 bar | −2 bar | −4 bar |
| ROC1 | 9.43(100) | 5.88(62) | 5.23(55) | 3.30(35) |
| ROC7 | 8.51(100) | 6.28(74) | 5.45(64) | 3.46(41) |
| ROC9 | 5.53(100) | 3.94(71) | 1.78(32) | 0.67(12) |
| ROC10 | 11.15(100) | 1.85(17) | 2.28(20) | 0.63( 6) |
| ROC12 | 6.55(100) | 4.49(69) | 3.59(55) | 2.40(37) |
| ROC13 | 5.62(100) | 3.92(70) | 1.66(30) | 0.74(13) |
| ROC15 | 4.05(100) | 2.87(71) | 2.31(57) | 1.61(40) |
| ROC16 | 3.63(100) | 1.59(44) | 0.56(15) | 0.38(10) |

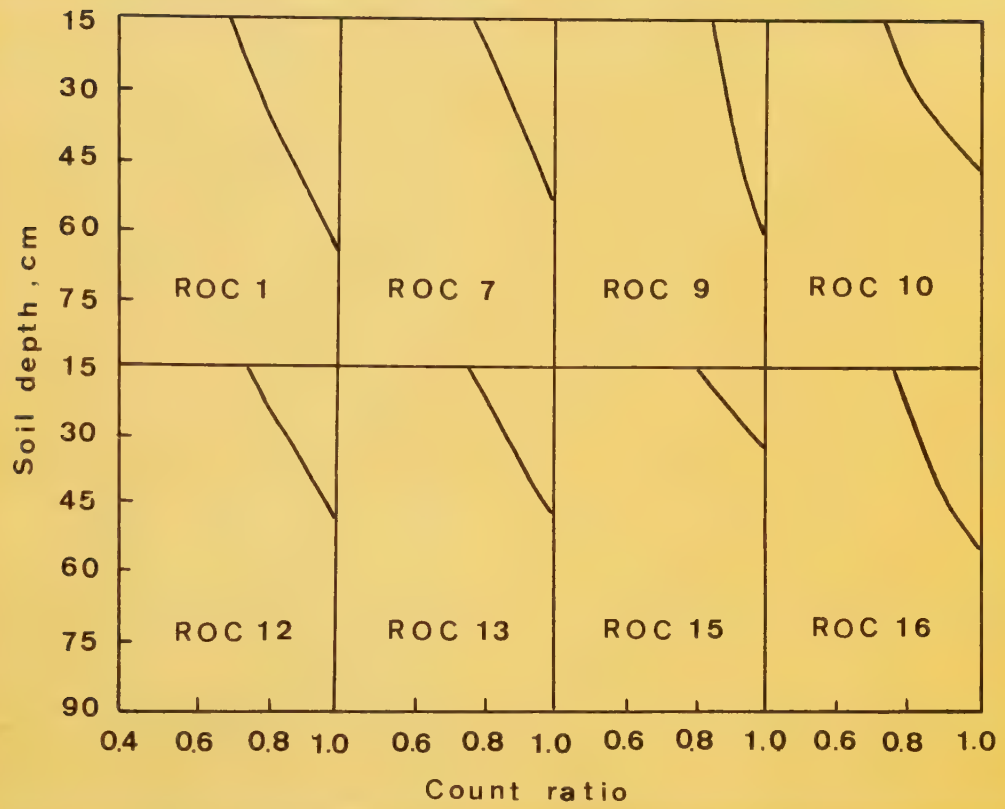



Fig. 5. Soil water depletion patterns of sugarcane varieties measured by neutron probe.

**Table 10. Field root distribution of autumn planting cane at 11 months**

| Variety | Root, fresh weight (g) | | | |
|---|---|---|---|---|
| | Depth of soil profile | | | |
| | 0–20 cm | 20–40 cm | 40–60 cm | 60–80 cm |
| ROC1 | 58.35 | 36.12 | 8.85 | 5.84 |
| ROC7 | 91.36 | 58.38 | 4.38 | 1.07 |
| ROC9 | 66.46 | 26.66 | 5.96 | 3.78 |
| ROC10 | 146.90 | 54.32 | 4.62 | 0 |
| ROC12 | 43.30 | 13.35 | 0.85 | 0.27 |
| ROC13 | 156.68 | 32.64 | 4.62 | 1.39 |
| ROC15 | 94.19 | 48.36 | 6.99 | 3.75 |
| ROC16 | 35.04 | 7.46 | 3.84 | 2.11 |

**Table 11. The ratings of drought resistance for sugarcane varieties**

| Item | Rating | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | ROC1 | ROC7 | ROC9 | ROC10 | ROC12 | ROC13 | ROC15 | ROC16 |
| Drought tolerance (1–5) | 4 | 5 | 2 | 1 | 5 | 2 | 5 | 2 |
| Water-depletion pattern (1–9) | 7 | 4 | 8 | 5 | 5 | 5 | 3 | 7 |
| Root-distribution pattern (1–9) | 8 | 1 | 9 | 2 | 3 | 4 | 8 | 9 |
| Drought resistance index* | 19 | 10 | 19 | 8 | 13 | 11 | 16 | 18 |

* Sum of the ratings of drought tolerance, water-depletion pattern, and root-distribution pattern. High values indicate high drought resistance.

## Effect of Lime Sludge Application on Growth and Metal Uptake of Sugarcane

Lime sludge from the Pingtung Pulp Factory was taken and its metal content was analyzed for metal quantities. Total concentrations of metals were determined by extraction with 4 M $HNO_3$ for 16 hrs at 80°C. The sludge was found to contain 23,070 mg Ca/kg, 1,286 mg Fe/kg, 118 mg Zn/kg, 62 mg Mn/kg, 30 mg Cu/kg, and 6 mg Cd/kg. Water soluble quantities of Zn, Mn, Cu, and Cd were less than 1 mg/kg while that of Pb was 1.5 mg/kg, as determined by the sequential extraction procedure developed by Sposito (1982). Over 95% of the metals were in an unlabile form, either the metal-organic complex of inorganic precipitating form. The lime sludge had a high calcium content resulting in the high pH of 12.2. Lime sludge application equivalent to 0, 25, 50, and 75 metric tons/ha on loamy soil (pH 5.8) and silt-loam soil (pH 8.0) revealed by the pot experiment that the application rate of 50 t/ha was the maximum the plants could tolerate. Higher application rates led to a decrease in cane yield. Plant tissue analysis indicated that metals accumulated in the plant in the following order of concentration: Mn > Cu > Zn > Cd. Cadmium, Cu, and Mn concentrations in the shoot were higher than those in the root; whereas, Zn was more concentrated in the root. (T. H. Weng, W. C. Liu and S. W. Li)

## Cadmium Uptake and Toxicity on Sugarcane

Rates of 0, 0.1, 5, 10, 20, 40, 80, 160, and 320 mg Cd/kg soil was applied to loamy soil (pH 5.8) and silt-loam soil (pH 8.0). Two single-bud sugarcane seedlings were planted in each soil. During the growing stages, the plants were irrigated with deionized water. The cane was harvested at 8 months of age. The sugarcane seedlings in the loamy soil with 320 mg Cd/kg soil did not survive. Cadmium contents in the sugarcane tissue and the soil saturation extract revealed that the accumulation of Cd in the root was proportional to the Cd application rate (Table 12). The Cd transfer coefficient (concentration of tissue Cd/soil Cd) varied from 2 to 6 in the loam and from 0.6 to 1.24 in the silt-loam. Cadmium concentration in the soil saturation extract ranged from 9.6 to 25.6 for loam and from 0.05 to 2.15 mg kg/soil for silt-loam. The Cd concentration in the sugarcane varied from 5.4 to 500 mg/kg for cane grown in loam and from 3.9 to 65 mg/kg for cane grown in silt loam.

**Table 12. The effect of application rate on Cd uptake of sugarcane**

| Application (mg/kg) | Cd in soil saturation extract (mg/kg) | | Cd concentration in tissue (ppm) | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Loam* | | | Silt loam | | |
| | Loam | Silt loam | Root | Stalk | Leaf | Root | Stalk | Leaf |
| Ck. | 0.03 | 0.045 | 7.5 | 0.4 | 0.4 | 7.0 | 0.8 | 0.8 |
| 0.1 | 0.05 | 0.040 | 5.4 | 0.8 | 0.6 | 3.9 | 2.0 | 1.0 |
| 5 | 0.31 | 0.041 | 30.0 | 7.8 | 5.8 | 6.2 | 2.1 | 1.2 |
| 10 | 0.31 | 0.043 | 41.5 | 8.2 | 6.2 | 9.7 | 3.3 | 1.5 |
| 20 | 1.13 | 0.043 | 41.7 | 19.3 | 10.5 | 12.1 | 3.5 | 2.6 |
| 40 | 1.55 | 0.044 | 88.7 | – | 17.3 | 41.3 | 4.5 | 2.8 |
| 80 | 2.45 | 0.048 | 250.0 | – | 18.3 | 90.0 | 4.6 | 3.8 |
| 160 | 9.60 | 0.055 | 550.0 | – | 91.2 | 106.3 | 4.7 | 4.4 |
| 320 | 25.60 | 2.150 | – | – | – | 265.0 | 8.7 | 4.6 |

*: – No tissue obtained.

The concentration of Cd in cane tissue was greatest in the root and lowest in the leaf. Stalk concentration was intermediate. Toxicity of Cd to sugarcane depended on soil CEC and Cd concentration in the soil solution. Phytotoxicity of Cd to sugarcane in loam with low soil CEC was more serious than that in silt loam with high soil CEC. (T. H. Weng, W. C. Liu and S. W. Li)

## Microcomputer Processing of Water Well Data

A PC-based multiple item query program on water wells has been developed to aid in water well management and pump efficiency analysis. Variable conditions allow special data searches. For instance, the specific capacities of a single tube well and a multiple siphon well can be compared.

The program is comprised of seven main items, namely: (1) item and number, (2) well body structure, (3) water level and discharge, (4) pump set, (5) aquifer and water quality, (6) measurement apparatus, and (7) execution. Each main item contains three to eight data fields, with a total of 50 data fields. The program is manipulated by selecting either a character or a direction function key. The result can be presented on a monitor or a printer. (C. F. Chen and Y. T. Fang)

## Improvement of A Wholestalk Seed Cane Harvester

The wholestalk seed cane harvester was modified in order to minimize bud damage and to strengthen the cross conveyor. A spring-supported guide plate for seed cane in flight was mounted where the rear upper roller of the hurler drum was originally located in order to reduce the interference action between the rollers. In addition, the belt conveyor was replaced with a roller chain conveyor. The new conveyor was a little heavier than the former but was much stronger. The blower position was also changed and was placed closer to a space between the hurler drum and the conveyor so as to blow more trash away.

Test results showed that the improved hurler drum efficiently threw the wholestalk cane to the roller chain conveyor (Fig. 6). The average bud damage to the harvested wholestalk seed cane was only 3%, which is acceptable as compared to damage during mechanical planting. (L. H. Huang)

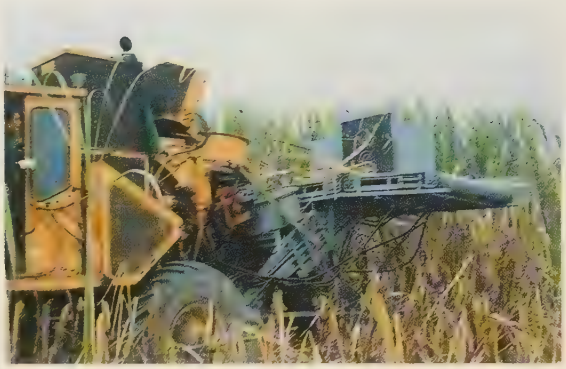


Fig. 6. Wholestalk seed cane harvester.

## Rapid Composting of Bagasse

It usually takes more than one year to complete bagasse composting by the piling method due to the high content of cellulose and lignin in the sugarcane stalk. The composting period of bagasse was cut down to 8–12 months by a forced-aeration system. The best ratio of air to bagasse was found to be 0.025 vvm on a volumetric basis. No offensive odors were released, and the peak temperature during composting was 45°C, which was 12°C higher than that of air.

Composting is also hindered because fresh bagasse is rich in carbon but not in nitrogen. In order to further speed up the bagasse decomposition rate, substrates with a high nitrogen content such as solid pig waste or alcoholic slops were incorporated into the bagasse. Bagasse was combined with solid pig waste or alcoholic slops at a 1 to 1 ratio. The mixed substrates maintained a temperature of 50°C or higher for 6 weeks (Fig. 7), and the temperature once reached 82° C during fermentation in a 14 $m^3$ composting house with a forced-aeration system. The volumetric loss was about 58% after composting for 11 weeks. Maturation of the compost of both bagasse-solid pig waste and bagasse-alcoholic slops occurred within only 4–5 months. (C. M. Huang, W. C. Chen, S. J. Chang, S. W. Li and L. H. Wang)

## Long Term Soil N Fertility Experiment

Since 1986, long-term field experiments on nitrogen fertility of sugarcane have been in progress. The nitrogen fertility was assessed using the hot water extraction method of testing for nitrogen availability. The content of hot-water-soluble N ($N_{hws}$) on the check plot (No N added) decreased 8.0% to 14.4% after three to five crops of sugarcane, as compared to the original N. However, as shown in Fig. 8, long term heavy nitrogen application did not result in $N_{hws}$ build up; the $N_{hws}$ remained at the same level. The soils of Shanhua, Kaohsiung, and Pingtung were found to have a low $N_{hws}$ content in the range of 15–21 ppm, whereas Chihu soils had a higher one. (I. J. Fang and T. S. Chao)

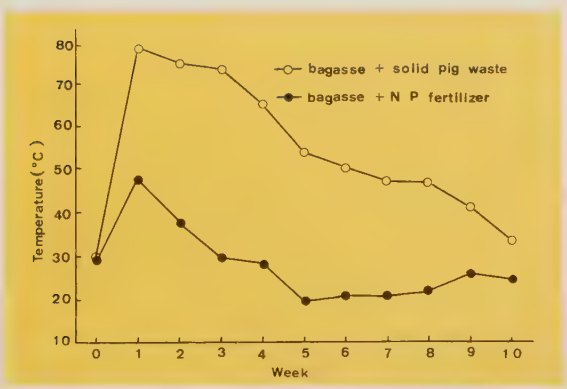



Fig. 7. Changes in average weekly temperature during the composting of bagasse.

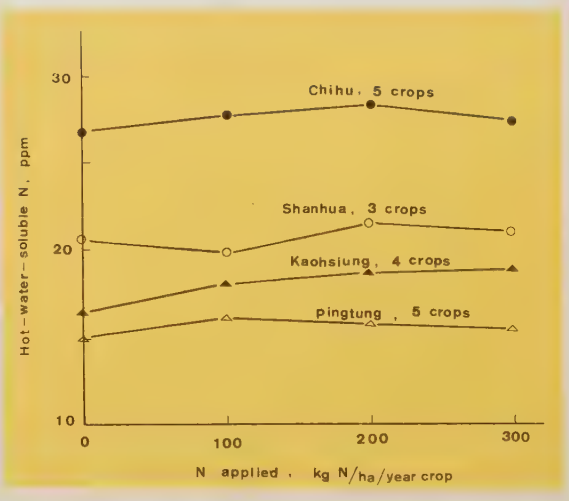



Fig. 8. The effect of N fertilizer application upon the hot-water-soluble N in soil.

**Table 13. Effects of alcoholic slops application on ratoon cane and sugar yield**

| Treatment | Application rate (t/ha) | Cane yield (t/ha) | ESG (%) | Sugar yield (t/ha) |
|---|---|---|---|---|
| No fertilizer | 0 | 48 | 15.31 | 7.35 |
| Control$^{+}$ | 0 | 102 | 14.94 | 15.24 |
| Basal dressing | 132 | 138$^{**}$ | 15.17 | 20.93 |
| | 264 | 121 | 13.90 | 16.82 |
| | 528 | 138$^{**}$ | 14.39 | 19.86 |
| Top dressing | 132 | 120 | 13.73 | 16.48 |
| | 264 | 99 | 13.20 | 13.07 |
| | 528 | 132$^{*}$ | 13.64 | 18.00 |

$^{+}$: Chemical fertilizers applied at normal rate.
$^{**}$: Statistically significant at 1% level.
$^{*}$: Statistically significant at 5% level.

## Effects of Alcoholic Slops on Soil Properties and Ratoon Cane Yield

Alcoholic slops contain many kinds of nutrient elements, such as N, P, K, Ca, Mg and others, which can help maintain soil fertility. Objectives of this pot experiment were to determine the effects of alcoholic slops on soil properties and ratoon cane yield. Sugarcane variety ROC10 was ratooned in pots in Dec. 1991 and harvested in Dec. 1992. Alcoholic slops were applied as a basal dressing after harvest or as a top dressing 3 months after harvest at the rates of 132, 264, and 528 t/ha. Alcoholic slops did not affect soil electrical conductivity or pH. The number and length of millable stalks in the pots treated with alcoholic slops were higher than in that of the control. Results indicated that cane and sugar yield can be increased without environmental pollution by suitably applying this waste liquid (Table 13). (P. L. Wang, Y. Y. Chan and S. J. Chang)

## Movement and Distribution of Heavy Metals in Soil Irrigated with Swine Lagoon Effluent

Soil samples belonging to six soil groups were collected from a swine lagoon effluent irrigation area to study heavy metal movement and distribution. The samples were analyzed for total and available quantities of Zn, Cu, Mn, Cd, Cr, Ni, and Pb. The results of 4 M $HNO_3$ digestion showed that the total concentrations of these metals in the tested soils were lower than the critical soil concentrations at which toxicity is considered possible. The quantities of these metals extractable with 0.1 N HCl ranged in the low-middle levels based on the criteria developed by the Environmental Protection Agency, ROC. The levels indicated that these metals were relatively available in the soils from sugarcane fields. The desorption potentials of metals in the different soil groups were calculated from the ratios of 0.1 N HCl extractable quantities to total quantities of the metals. As shown in Table 14, the desorption potentials differed with soil type.

The GEOCHEM and MIXTURE models predicted that facultatively treated swine lagoon effluents differed in chemical composition and in speciations of metals from anaerobically treated effluents. In the former, nitrogen existed primarily as $NO_3^-$; Zn and Mn were dominated by free ions; Cu and Fe existed as organo-complexes;

**Table 14. The desorption potentials of heavy metals in different soil types**

| Metal | Sequence of desorption potentials in soil types |
|---|---|
| Zn | $AS_c > H_c > R > AT > AS_n > ATL$ |
| Cu | $AS_c > AT > AS_n = H_c > R > ATL$ |
| Mn | $AS_c > H_c > AT > ATL > R = AS_n$ |
| Cd | $AT > AS_c > H_c > AS_n = ATL > R$ |
| Cr | $AT > AS_n = AS_c > ATL > R > H_c$ |
| Ni | $AS_c = AT > H_c > ATL > AS_n = R$ |
| Pb | $AS_c > AS_n = ATL = AT = H_c > R$ |

$AS_c$ = sandstone-shale calcareous alluvial soil.
$AS_n$ = sandstone-shale non-calcareous alluvial soil.
AT = slate alluvial soil.
ATL = sandstone-shale slate alluvial soil.
$H_c$ = low humic gray soil.
R = red soil.

and Ni was either free (50%) or in complexes with carbonate or organic acid (20% for each). In the latter, nitrogen existed primarily as $NH_4^+$; Zn, Fe, Mn, and Ni were dominated by carbonate; and Cu existed as organo-complexes. When acidic soil was irrigated with swine lagoon effluent, Zn existed in the soil primarily as a free ion, and Cu was complexed with organic substances. In an alkaline soil, only 18% of the Zn existed as a free ion with the remaining 78% complexed with hydroxide, and 25% of the Cu was complexed with $NH_3$ with 74% of Cu found in organo-complexes. In fields irrigated with swine lagoon effluent, the extent of metal adsorption by soils and uptake by plants can be expected to differ with effluent source and soil type. (W. C. Liu and S. W. Li)

# *Horticulture*

### Breeding of *Phalaenopsis*

1. Collection and registration of germplasm

   From June 1992 to June 1993, 237 clones were collected. A total of 837 clones and 29 wild species have now been preserved at the Taiwan Sugar Research Institute (TSRI). The horticultural characteristics of each of the new clones have been added to the computer database to allow easy access for breeding. For example, the heavily spotted and well shaped, *Phal.* Stone Pinto 'TSC20' (Fig. 9), the easily flowering and intensely red-colored, *Phal.* Taisuco Leinhung 'F82-14' (Fig. 10), and the brightly striped *Phal.* [(Paifang's Auckland × Golden Amboin) × Chih Shang's Stripes] 'A82-37' (Fig. 11) were some of the parents used for the improvement and production of new commercial varieties.

   Twenty five excellent hybrids (Table 15) that are being used to produce commercial seedlings were registered with the first name

Fig. 9. *Phal.* Stone Pinto 'TSC20' won the Bronze Medal in Japan Grand Prix International Orchid Festival in 1993.

Fig. 10. Flowering of *Phal.* Taisuco Leinhung 'F82-14' selected from TS159.

Fig. 11. *Phal.* [(Paifang's Auckland x Golden Amboin) x Chih Shang's Stripes] 'A82-37' showing orange flower with reddish stripes.

of 'Taisuco' (Taiwan Sugar Corporation) at the Royal Horticultural Society (RHS). A total of 33 crosses have been registered since 1991.

2. Crossing, seedling raising and clonal selection

The sexual crosses made during 1992-1993 were aimed at breeding excellent varieties with red flowers and with white flowers with red lips. More than 150 crosses were made for this purpose, and 75 crosses were fertile.

**Table 15. Excellent hybrids bred by TSRI registered at RHS in 1993**

| Color | Grex registered | Parents |
|---|---|---|
| R | *Phal.* Taisuco Candy | *Phal.* (Morgenrose x *equestris*) |
| R | *Phal.* Taisuco Perherz | *Phal.* (Pinglong Perfection x Lippeherz) |
| R | *Phal.* Taisuco Lienhung | *Phal.* (New Eagle x Lienhung Rose) |
| R | *Phal.* Taisuco Eagle | *Phal.* (Taisuco Lienhung x New Eagle) |
| R | *Phal.* Taisuco Roseherz | *Phal.* (Zauberrose x Lippeherz) |
| R | *Phal.* Taisuco Lady | *Phal.* (Lienhung Pink x Taisuco Gaster) |
| R | *Dtps.* Taisuco Redwine | *Dtps.* (*Phal.* Taisuco Lienhung x Taisuco Beauty) |
| R | *Phal.* Taisuco Hatarot | *Phal.* (Keiko Hatano x Zauberrot) |
| R | *Dtps.* Taisuco Sweet | *Dtps.* (Happy Valentine x Taisuco Beauty) |
| R | *Dtps.* Taisuco Honey | *Dtps.* (*Phal.* Taisuco Hatarot x Taisuco Beauty) |
| R | *Dtps.* Taisuco Red | *Dtps.* (*Phal.* Taisuco Hatarot x Happy Valentine) |
| R | *Dtps.* Taisuco Precocity | *Dtps.* (Hama Lip x *Phal.* Taisuco Hatarot) |
| R | *Phal.* Taisuco Apple | *Phal.* (Pinlong Davis x Lien-Hung Rose) |
| R | *Phal.* Taisuco Pink | *Dtps.* (*Phal.* Mount Kaala x Taisuco Beauty) |
| R | *Dtps.* Taisuco Rubby | *Dtps.* (*Dor. pulcherrima* x *Phal.* Taisuco Gaster) |
| W | *Phal.* Taisuco Doll | *Phal.* (Taisuco Bright x *amabilis*) |
| W | *Phal.* Taisuco Windian | *Phal.* (Winter Kaala x Taisuco Kochdian) |
| W | *Phal.* Taisuco Kaaladian | *Phal.* (Mount Kaala x Taisuco Kochdian) |
| W | *Phal.* Taisuco Clouds | *Phal.* (Hawaiian Clouds x Taisuco Bright) |
| WR | *Dtps.* Taisuco Truelip | *Dtps.* (*Phal.* True Lady x Hama Lip) |
| WR | *Dtps.* Taisuco Redlip | *Dtps.* (*Phal.* True Lady x Dalin Beauty) |
| WRS | *Phal.* Taisuco Blacea | *Phal.* (Taisuco Bright x *violacea*) |
| WRS | *Phal.* Taisuco Smile | *Phal.* (Taisuco Bright x *equestris*) |
| O | *Phal.* Taisuco Riosan | *Phal.* (Rio's Golden Ho x Cassandra) |
| Y | *Phal.* Taisuco Lemon | *Phal.* (Lemon Pie x Golden Amboin) |

R = Red flower.
WR = White flower with red lip.
O = Orange flower.
WRS = White with red spray.
Y = Yellow flower.

Fig. 12. TS244, *Phal.* Taisuco Red flowering in March.

Fig. 13. TS349, *Phal.* (Taisuco Gaster x *equestris*), flowering in November.

Some crosses made before 1991 showing high uniformity and quality in their populations were selected and released to the Nursery Center for mass production of commercial seedlings. For example, TS244 (Fig. 12) which is well-shaped and has good substance in the flower is assessed to be a major red flower variety. TS349 (Fig. 13) and TS378, small red flowers derived from *Phal. equestris,* which are easily grown and have a short juvenile stage are high in commercial value. TS349 is suitable as a pot flower during the Chinese New Year, and TS378, with an attractive fragrance, has superior potential for the market.

3. Prizes at international orchid shows in 1993

Many clones were exhibited in several orchid shows in 1993 (Table 16). *Phal.* Stone Pinto' TSC20 ' (Fig. 9) won the bronze med-

**Table 16. Prizes won at international orchid shows in 1993**

| Clone | Prize |
|---|---|
| *Phal.* Stone Pinto 'TSC20' | BM/JGPIOF |
| *Phal. equestris* 'Dark' | Trophy /7th IOSOT |
| *Dtps.* [*Phal.* (Arai x Matou Freed) x Happy Valentine] 'A80-069' | 1st place /7th IOSOT |
| *Dtps.* (Day Break x P. Strawberry Love) 'TSC14' | 2nd place /7th IOSOT |
| *Phal.* Carmela's Pixie 'TSC17' | 2nd place /7th IOSOT and CCM |
| *Phal.* [*stuartinana* x (Paifang's Auckland x Golden Amboin)] 'A82-072' | 2nd place /7th IOSOT |
| *Phal.* Stone Pinto 'B82-012' | 2nd place /7th IOSOT |
| *Phal.* Little Steve 'A78-84' | 3rd place /7th IOSOT and AM/AOS |
| *Phal.* Atien Kaala 'TSC8' | 3rd place /7th IOSOT and AM/AOS |
| *Phal.* Maraldee 'B79-030' | 3rd place /7th IOSOT |
| *Phal.* Carmela's Pixie 'C80-006' | 3rd place /7th IOSOT |
| *Phal.* Hsiang Fei 'TSC18' | 3rd place /7th IOSOT |
| *Dtps.* Sun Chen Beauty 'A82-071' | 3rd place /7th IOSOT |
| *Phal.* Stone Pinto 'B82-006' | 3rd place /7th IOSOT |
| *Phal.* Stone Pinto 'TSC19' | 3rd place /7th IOSOT and AM/AOS |
| *Phal.* Stone Pinto 'B82-014' | 3rd place /7th IOSOT |
| *Phal.* Stone Pinto 'F82-010' | 3rd place /7th IOSOT |
| *Phal.* Taisuco Riosan | 3rd place /7th IOSOT |
| *Phal.* Taisuco Kaaladian 'TSC27' | AM, trophy, 1st place and |
| | 1st place excellent variety/ 14 WOC |
| | 1st place /14 WOC |
| *Phal. amabilis* 'TSC53' | 1st place /14 WOC |
| *Phal.* Liu Tuen Shen 'TSC40' | 1st place /14 WOC |
| *Phal.* Golden Emperor 'Sweet' | 1st place /14 WOC |
| *Phal.* Budi Linuhung 'Chin Fang' | 1st place /14 WOC |
| *Phal.* Little Steve 'Brother' | 2nd place /14 WOC |
| *Dtps.* Sun Chen Beauty 'TSC51' | 2nd place /14 WOC |
| *Phal.* Taisuco Lemon 'TSC47' | 3rd place /14 WOC |
| *Phal.* Brother Stripes 'Tainan Beauty' | 3rd place /14 WOC |
| *Phal.* Stone Pinto 'TSC21' | 3rd place /14 WOC |

JGPIOF = Japan Grand Prix International Orchid Festival, 1993.
IOSOT = International Orchid Show of Taiwan, 1993.
14 WOC = 14th World Orchid Conference, 1993.
AM = Award of Merit.
BM = Bronze Medal.
CCM = Certificate of Cultural Merit.

Fig. 14. *Phal.* Taisuco Kaaladian 'TSC27' won AM, trophy, and 1st place at the 14th World Orchid Conference in 1993.

al in the Japan Grand Prix International Orchid Festival. At the seventh International Orchid Show of Taiwan (IOSOT), 17 clones gained 20 prizes. Both *Phal.* Atien Kaala 'TSC8' and *Phal.* Stone Pinto 'TSC19' won the award of merit of the America Orchid Society (AOS). And at the 14th World Orchid Conference and Show in Glasgow, 10 clones gained 13 prizes. The most distinguished clone was *Phal.* Taisuco Kaaladian 'TSC27' (Fig. 14) which won the silver award, the trophy, and first place in the excellent white *Phalaenopsis* hybrid category. The many awards received in international orchid shows in 1993 confirm the achievement of *Phalaenopsis* breeding at TSRI.

4. Studies of DNA amplification fingerprinting in *Phalaenopsis*

A method of DNA amplification fingerprinting (DAF) based on the DNA polymerase chain reaction (PCR) has been developed to identify different varieties of *Phalaenopsis*. The molecular markers serve to protect patent rights to new *Phalaenopsis* varieties from Taiwan Sugar Corporation.

This method uses DNA extracted from a trace amount of leaf material. A polymorphism in the DAF patterns of orchid was observed among different genera (Fig. 15), different species in the same genus (Fig. 16), and different clones in the same species (Fig. 17) when a suitable primer was used for the PCR reaction. The greater the genetic distance, the more easily a suitable

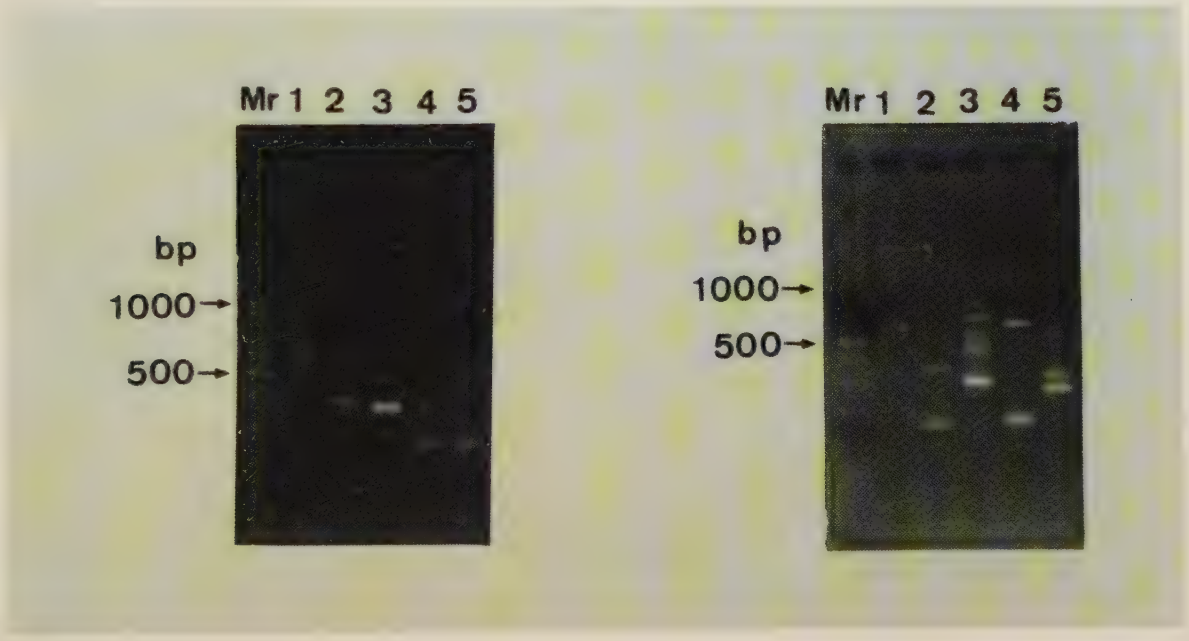



Fig. 15. DAF patterns of different genera in *Orchidaceae* show that five genera of orchid were distinguished easily by both banding location and banding numbers.
A: primer OPF-6 (5'-GGG AAT TCG G-3')
B: primer S-3 (5'-TCT TGG GAA GGC ACT TCC TT-3')
1: *Phalaenopsis* 2: *Doritis* 3: *Cattelya* 4: *Dendrobium* 5: *Cymbidium*

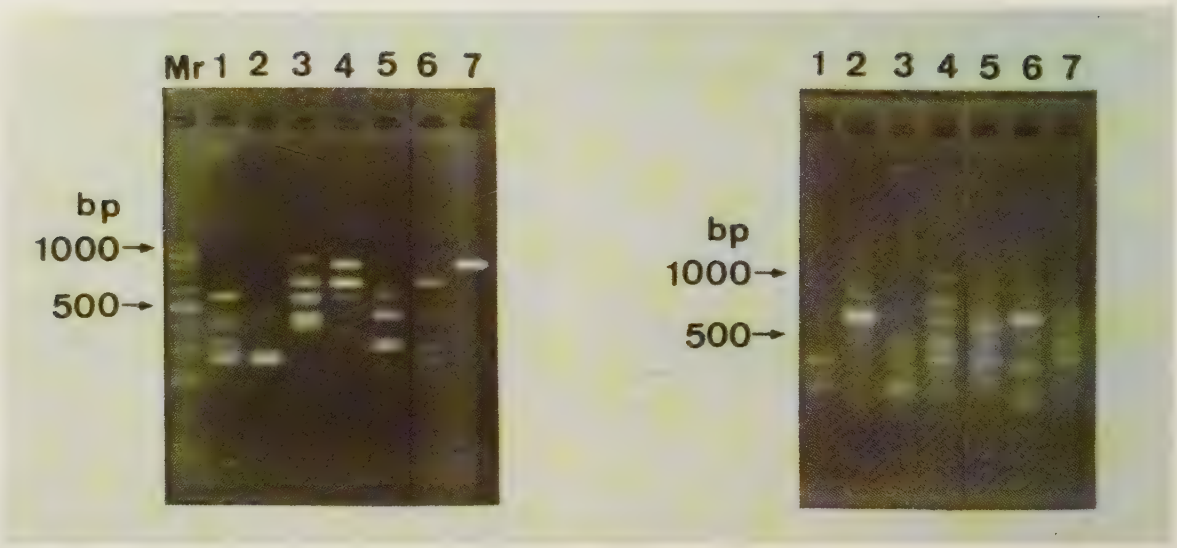



Fig. 16. DAF patterns of different wild species in *Phalaenopsis* and *Doritis*. Patterns in different species are more similar than that in different genera.
A: primer OPF-1 (5'-ACG GAT CCT G-3')
B: primer S-4 (5'-AAG ACG GCG ACG AGC TCA TT-3')
1: *Phal. amabilis* 2: *Phal. amboinensis* 3: *Phal. aphrodite* 4: *Phal. equestris* 5: *Phal. lueddemanniana* 6: *Phal. violacea* 7: *Doritis pulcherrima*

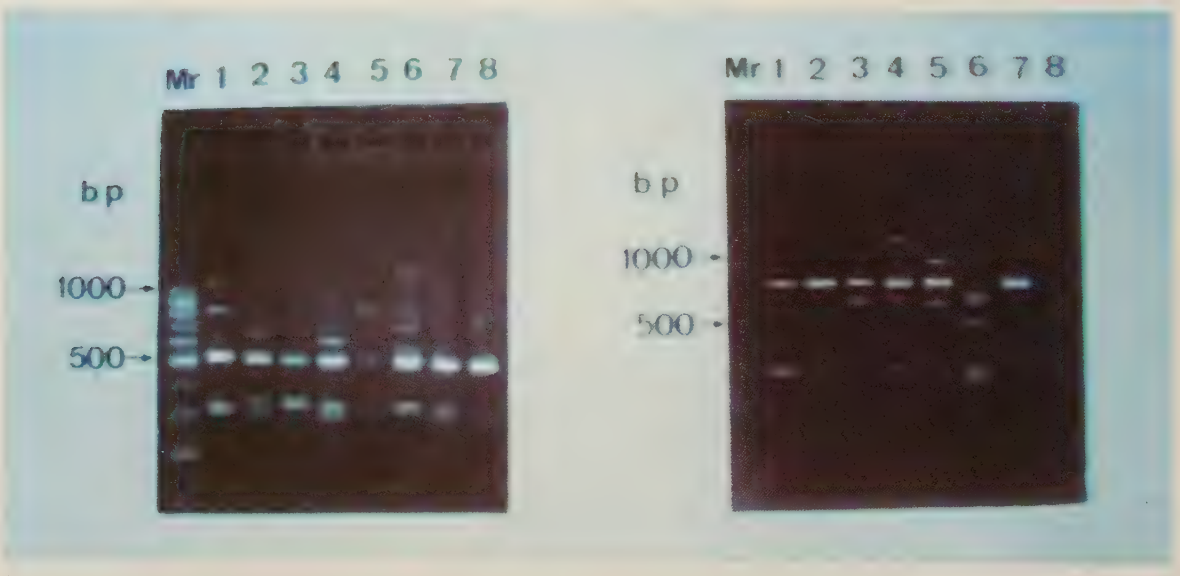



Fig. 17. DAF patterns of different clones in *Phal. equestris*. Most of the banding is similar. There are a 500 bp band and a 750 bp band in most of the clones with OPF-5 primer (A) and OPF-6 primer (B), respectively.
A: primer OPF-5 (5'-CGG AAT CCT C-3')
B: primer OPF-6 (5' GGG AAT TCG G-3')
1: W9-9 2: W9-12 3: W9-27 (Ilocos) 4: W9-44(Appari) 5: W9-49 (Alba) 6: W9-52 7: W9-55'Dark' 8: W9-56

primer which distinguished the DAF patterns could be selected. Yet, no matter how similar the genetic background, distinguishable bands in DAF patterns among the varieties were obtainable if a suitable primer was used. It is concluded that DAF is a powerful and useful tool for protecting patent rights of new varieties of *Phalaenopsis*. (W. H. Chen, Y. M. Fu, R. M. Hsieh, C. C. Wu and M. S. Chyou)

### Effect of Bonzi on the Flowering of *Phalaenopsis*

The long flower stalks of *Phalaenopsis* make them difficult to package and occupy a large volume during transportation from nursery to market. It was found that Bonzi, a plant growth regulator, dwarfed the flower stalks but did not affect the flower size or number of flowers when sprayed at a concentration of 250 ppm on the plants before flowering (TSRI Annual Report 1989/1990 p. 17). However, this spraying method resulted in shortening new leaves and new roots (Fig. 18) which would reduce the market value of the pot plants. A smearing method has been developed to resolve this problem in which the whole young flower stalk is brushed with 200 ppm Bonzi solution. Table 17 shows that the flower stalk was shortened by about 1/3 of the length by this smearing method, and Fig. 19 shows that the new leaf was not affected by the Bonzi treatment. (M. S. Chyou)

Fig. 18. The shortened new leaves and roots of *Phalaenopsis* resulted from spraying the Bonzi on the whole plants.

Fig. 19. The dwarf flower stems of *Phal.* Angel Smile resulted from smearing the Bonzi on the flower stems.

### Automated Production of *Phalaenopsis*

1. Automatic control of the greenhouse environment

A system to automatically control the greenhouse environment was developed during the past few years to reduce installation costs, increase service functions, simplify operations, and solve maintenance problems. Stepwise refinement is still in progress. This year, the functions of the system were extended to manipulate sixteen greenhouses. The interface circuit was integrated into one board for each greenhouse. On-line tests were available for data processing and for on/off control of the greenhouses. This system was commercialized and technically put out to lease with a private company for three years starting 15 October 1992.

**Table 17. The effect of Bonzi on the flowering of *Phalaenopsis* Angel Smile**

| Treatments | No. of plants | Stalk length (cm) | Stalk diameter (cm) | No. of flowers per plant | Flower size (cm) |
|---|---|---|---|---|---|
| Bonzi 200 ppm (by smearing method) | 14 | 53.4 | 0.446 | 21.7 | 6.2 |
| Check (non-treatment) | 6 | 75.5 | 0.477 | 26.3 | 6.6 |

2. A transportable bench system

Manual transportation of plants is very labour intensive at the time of peak activity in production of *Phalaenopsis*. Hence, a transportable bench system (Fig. 20) to move benches between the greenhouse and the working station for potting and repotting *Phalaenopsis* plants was under development and fabrication. The system consisted of transportable aluminum benches, a pipe track system, a transfer-elevation device (TED), and a rear transit mechanism (RTM). In order to get the most benefit from this system, some operations such as irrigation, fertigation, and chemical application and also the seedling nursery were designed in the working station so as to (1) improve operation efficiency, (2) save water and labor, (3) increase source recycling, and (4) reduce polluted material for environmental protection. The performance of the overall process within this system is still under evaluation. Further study will be focused on the time required for each operation and for the bench transportation. (T. J. Huang, C. L. Pan, M. H. Jean and W. H. Chen)

Fig. 20. An automatic environment-controlled greenhouse with a transportable bench system.

## Off-Season Production of *Phalaenopsis* Flower

The effect of thermal treatment on the induction and inhibition of flower stalk emergence at different times was investigated using the facility developed by TSRI (Chinese patent no. 69590) for the control of flowering in *Phalaenopsis*.

A cooling treatment was conducted on 15 May and 12 Aug. 1992 to induce emergence of the flowering stalk. The temperature was maintained at 25°C during the day and 20°C at night. As shown in Table 18, plants treated in May had a lower rate of stalk emergence and fewer flowers than those treated in August. This is because in May the plants had not had enough recovery time after their previous natural flowering to gain sufficient energy to flower again successfully.

**Table 18. Effect of cooling treatment on stalk induction of *Phalaenopsis***

| Date (y/m) | Hybrid | Rate of stalk emergence (%) | | No. of flowers per plant* | Length of stalk (cm) |
|---|---|---|---|---|---|
| | | 30 days | 60 days | | |
| 1992/05 | S77-2 | 10 | 54 | 4.0 | 48 |
| | S78-8 | 66 | 98 | 5.1 | 54 |
| 1992/08 | S77-2 | 54 | 94 | 8.7 | 64 |
| | S77-3 | 62 | 92 | 8.8 | 67 |
| | S79-98 | 80 | 96 | 6.2 | 57 |
| | S79-172 | 80 | 100 | 5.2 | 53 |

* Flowers and buds at the 120th day after treatment.

Inhibition of the natural flowering of *Phalaenopsis* with a heat treatment from 15 Dec. 1992 to 15 Mar. 1993 was studied using three hybrids of *Phalaenopsis*, TS223, S77–2, and S78–8. Only a few flower stalks emerged during the early stage of treatment. By pinching off the flower stalks on 31 Dec., no further growth of the flower stalks was observed. The results showed that the method completely inhibited stalk emergence of the plants during the natural flowering season. This method would allow the plants to produce quality off-season flowers. (M. H. Jean, H. W. Ho, L. Yang, T. J. Huang, C. L. Pan and W. H. Chen)

### Vase Life of Cut Flowers in Different *Phalaenopsis* Clones

The vase life of the cut flowers of four mericlones, *Phal.* Joseph Hampton 'Diana', *Phal.* Mount Kaala 'B78–3', *Phal.* Mount Kaala 'B78–5', and *Phal.* Mount Kaala '715', from Wusulin orchid nursery was investigated. Fifty stalks of each clone were selected. Each stalk, bearing 5–7 flowers, was cut to 65 cm length, and immediately inserted into Tan-Yi No.1 solution for 2 hrs for pretreatment. Then they were transferred to Tang-Pau No.1 preservative solution and placed in growth chambers at 25°C for observation.

The results indicated that the vase life of *Phal.* Joseph Hamptom was the longest, as it did not wilt until the 11th day after treatment (Table 19). However, it was found that 16.4% and 24.6% of the flowers had wilted on the 15th and 19th day after treatment, respectively. *Phal.* Mount Kaala 'B78–3', *Phal.* Mount Kaala 'B78–5', and *Phal.* Mount Kaala '715', were sister clones. Wilt caused by insufficient water uptake did not occur in these varieties during this period of study. *Phal.* Mount Kaala 'B78–5' had a better vase life than the other sister clones. During further investigation on the variation in water uptake (Fig. 21), it was found that the daily water uptake of the cut flowers of the four varieties decreased gradually after treatment. Greater water uptake was correlated with longer vase life. The abrupt increase in water uptake of *Phal.* Joseph Hamptom on the 19th day after treatment may be due to rapid transpiration which occurred at that time. Further studies are necessary to understand the water equilibrium between absorption and transpiration in cut flowers.

*Phal.* Joseph Hamptom 'Diana' and *Phal.* Mount Kaala 'B78–3', 'B78–5' and '715', are mericlones derived from two hybrids. The vase life of these two hybrids was different. In addition, *Phal.* Mount Kaala 'B78–3', *Phal.* Mount Kaala 'B78–5' and *Phal.* Mount Kaala '715' are different clones from the same hybrid, and the vase life also differed among these sister clones. Hence, careful selection of commercial mericlones for cut flower production is important. (L. Yang and F. W. Ho)

**Table 19. Percent wilting of cut flowers of *Phalaenopsis* clones**

| Clone | Days after treatment | | | | | |
|---|---|---|---|---|---|---|
| | 4 | 7 | 11 | 15 | 19 | 32 |
| Joseph Hamptom 'Diana' | 0 | 0 | 0 | 16.4 | 24.6 | 29.9 |
| Mount Kaala 'B78–3' | 0 | 0 | 3 | 5.3 | 6.0 | 39.8 |
| Mount Kaala 'B78–5' | 0 | 0.7 | 3.4 | 3.4 | 3.4 | 27.9 |
| Mount Kaala '715' | 0.8 | 3.4 | 8.5 | 3.4 | 16.9 | 46.6 |

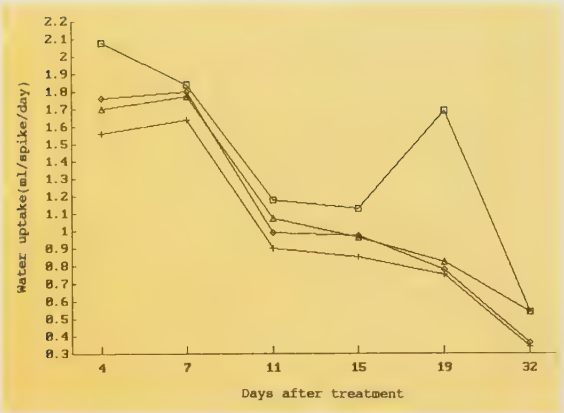



Fig. 21. The variation in water uptake per cut flower per day of *Phalaenopsis* clones.

## Seed Transmission of Cymbidium Mosaic Virus and Odontoglossum Ringspot Virus

The parents in six crosses were infected with cymbidium mosaic virus (CyMV) or odontoglossum ringspot virus (ORSV), and the resulting seeds were sown serially on G7, T2, and L8 media according to the culture method established by the breeding laboratory in the Department of Horticulture, TSRI. These flask seedlings were transplanted into 1.5-inch pots singly and were cultivated in the greenhouse. The original and the new-born leaves were sampled to detect CyMV and ORSV using the ELISA (enzyme-linked immunosorbent assay) technique after 1, 10, and 12 months growth. Neither virus was detected in the 1-month-old seedlings. Of the 342 tested seedlings from three crosses of parent plants infected with CyMV, four 10-month-old seedlings reacted positively to the ELISA test. Of the 279 tested seedlings from three crosses of parent plants infected with ORSV, two 10-month-old seedlings reacted positively to the ELISA test. However, none of the infected seedlings were found to have CyMV or ORSV when they were tested again at 12 months of age (Table 20). The reason is not understood and needs to be studied further. (G. C. Wey)

## Effects of Methyl Bromide Fumigation on *Saissetia coffeae* and *Tenuipalpus pacificus*

There are many insect and other animal pests of the *Phalaenopsis*. The scale insect, *Saissetia coffeae*, the springtails, the mite, *Tenuipalpus pacificus*, and *Bekkochlamys teramachi* are the most important pests attacking the leaves, flowers, or peduncle. Severe infestations on the plant result in the growth of black mold, and thus yellowing and falling of the leaves. In addition, the infestation of *S. coffeae* always results in the appearance of black mold on the flowers, completely destroying their commercial value.

*Phalaenopsis* plants infected with *T. pacificus* and *S. coffeae* were packed in paper boxes and placed in different locations in a fumigation room ($2.6 \times 2.6 \times 6.1$ m) and fumigated with 1000 g methyl bromide for 3 hrs. The paper boxes with

**Table 20. Occurrence of viruses in F1 seedlings derived from parent plants infected with CyMV and ORSV**

| Virus in parents | No. of crosses | No. of seedlings detected | Infection rate in seedlings of different ages (%) | | |
|---|---|---|---|---|---|
| | | | 1 month | 10 month | 12 month |
| CyMV | 3 | 342 | 0 | 1.2 | 0 |
| ORSV | 3 | 279 | 0 | 0.7 | 0 |

*Phalaenopsis* plants were then moved to the insectary where they were maintained at 24–25°C. After 4 and 8 days the boxes were opened to inspect the mortality rates of the pests. The results are shown as Tables 21 and 22. The fumigated plants were also moved into the greenhouse to examine their growth rate and flower quality.

*T. pacificus* and *S. coffeae* were completely killed by the fumigation with methyl bromide regardless of the site of infestation, location in the fumigation room, or stage of insect development. Methyl bromide fumigation was shown to be an excellent control method for these two pests. It was also found that the fumigated plants grew and bloomed normally. (S. L. Yang and L. Yang)

**Table 21. Effects of methyl bromide fumigation on *Tenuipalpus pacificus* (4 and 8 days later)**

| Location of plants in the fumigation room | Mortality* (%) | | Percent emerged |
|---|---|---|---|
| | Larval stage | Nymph stages | |
| Upper right front | 100 | 100 | 0 |
| Lower right front | 100 | 100 | 0 |
| Upper middle | 100 | 100 | 0 |
| Lower middle | 100 | 100 | 0 |
| Upper right back | 100 | 100 | 0 |
| Lower right back | 100 | 100 | 0 |
| CK (4 days later) | 9.9 | 9.1 | 75.4 |
| CK (8 days later) | 12.9 | 6.1 | 70.0 |

* Leaf numbers 2 and 4 were investigated.

**Table 22. Effect of methyl bromide fumigation on *Saissetia coffeae* (4 and 8 days later)**

| Location of plants in the fumigation room | Mortality (adults and nymphs), % | | | | | | Peduncle | Percent emerged |
|---|---|---|---|---|---|---|---|---|
| | Spindle | +1 | +2 | +3 | +4 | +5 | | |
| Upper right front (4 days later) | 100 | 100 | 100 | 100 | 100 | – | 100 | 0 |
| Lower right front (4 days later) | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 0 |
| Upper middle (8 days later) | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 0 |
| Upper left back (8 days later) | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 0 |
| Lower left back (8 days later) | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 0 |
| CK | 0 | 2.0 | 2.4 | 1.4 | 2.2 | 0 | 1.5 | 75.0 |

### Effect of Planting Media on the Growth of Anthurium Seedlings

Three kinds of processed bagasse, produced by Department of Biotechnology, Taiwan Sugar Research Institute, were used as planting media for planting anthurium seedlings; peat moss and smoked rice husk were used as checks. Anthurium seedlings about 10 cm high were planted in a 3-inch pot. The potted plants were placed under an overhead spray irrigation system or an ebb and flow irrigation system. New leaf emergence and leaf length were recorded monthly. Growth response was shown by average leaf emergence and leaf length (Table 23).

The growth of anthurium seedlings under the ebb and flow system was better than that under the overhead spray system. Under the ebb and flow system, there were no differences in leaf emergence among the different media treatments; however, under the overhead spray system, the leaf emergence rate was greater in smoked rice husk than in the other media. The leaf length from smoked rice husk was greater than that from the other treatments with both the ebb and flow system and the overhead spray system. The processed bagasse fibers were found to be feasible for use as planting media. However, because it rots easily, it should be mixed with other durable materials. Intensive studies should also be done on management of watering and fertilization in the growing of anthurium. (J. B. Chen, W. H. Chen, L. Yang and G. D. Wu)

### Effect of Organic Fertilizer on Growth and Quality of Small Paitsai Growing in Nutriculture Boxes

In order to study the effect of organic fertilizer added to the nutrient solution on the growth and quality of small paitsai grown in the Taisuco nutriculture box (Chinese patent no. 76379), 15 plants of small paitsai were planted in each box, and the organic fertilizer, Humus Guano (HG), was added to the normal nutrient solution. The application levels of HG were 10 g, 20 g and 30 g per box, replicated two times. The plants were harvested 4 weeks after sowing. The yield of each box was recorded and samples were taken for chemical and nutritional analysis to compare the elemental and nutritional components in the plants among the treatments and between soil culture and nutriculture. Results are listed in Tables 24–26.

It was found that the yield of small paitsai did not increase with the addition of HG organic fertilizer to the nutrient solu-

**Table 23. Effect of different media on growth of anthurium seedlings***

| Treatment | Ebb and flow | | Overhead spray | |
|---|---|---|---|---|
| | Leaf emergence (no.) | Leaf length (cm) | Leaf emergence (no.) | Leaf length (cm) |
| Bagasse #25 | 3.0 | 9.2 | 1.8 | 6.3 |
| Bagasse #38 | 3.0 | 9.1 | 2.2 | 4.6 |
| Bagasse #42 | 3.0 | 9.9 | 1.8 | 6.1 |
| Smoked rice husk | 3.0 | 10.4 | 3.3 | 7.2 |
| Peat moss | 3.0 | 9.0 | 2.0 | 5.9 |

* Over a 5-month growing period.

**Table 24. Effect of Humus Guano (HG) on yield and solution consumption of small paitsai growing in the nutriculture box**

| Treatment | Yield (g/box) | Dry weight (g/box) | Solution consumption (ml/g dry weight) |
|---|---|---|---|
| No HG (check) | 1,470 | 120.25 | 93.81 |
| 10 g HG added | 1,370 | 106.92 | 103.24 |
| 20 g HG added | 1,405 | 109.48 | 108.91 |
| 30 g HG added | 1,335 | 105.67 | 105.85 |

tion (Table 24). The dry weight accumulation of the check (without HG) was greater than that of the other treatments. The solution consumption rate of the check was lower than that of the other treatments.

There were few differences among the nutriculture treatments in the mineral content of the edible parts of the small paitsai (Table 25). However in the farmer soil cultured paitsai, the concentration of potassium and magnesium was around 70% lower and the concentration of other mineral elements was higher, phosphorus 123%, iron 133%, manganes 211%, copper 223% and zinc 517% than in the paitsai grown in nutriculture.

Table 26 shows the nutritional contents of the edible parts of the small paitsai grown in the different treatments. A slightly higher protein content and a lower raw fiber content were found in the farmer soil culture than in that of nutriculture. The carotene concentration of the plants growing in nutriculture containing HG was higher than both the non-HG added treatment and the farmer soil culture. However, the vitamin C content was found to be highest in the farmer soil culture, lower in the HG added treatments, and lowest in the non-HG added treatment. The chlorophyll concentration was higher in the HG added treatments but lower in the non-HG added nutriculture and the farmer soil culture. Only a trace of sucrose and starch could be detected in any of the samples.

The results show that the Taisuco nutriculture box is a practical growing kit to produce high quality vegetables free from pesticide contamination. It seems the quality or the nutritional value of the vegetables could be improved by supplementing some organic components to the nutrient solution. (J. B. Chen and G. D. Wu)

**Table 25. The mineral content of small paitsai under different treatments in nutriculture and farmer soil culture***

| Treatment | N (%) | P (%) | K (%) | Ca (%) | Mg (%) | Fe (ppm) | Mn (ppm) | Zn (ppm) | Cu (ppm) |
|---|---|---|---|---|---|---|---|---|---|
| No HG (check) | 6.15 | 0.74 | 5.05 | 2.79 | 0.59 | 454.75 | 77.35 | 36.55 | 5.30 |
| 10 g HG added | 6.47 | 0.79 | 7.08 | 2.60 | 0.70 | 593.00 | 84.60 | 33.75 | 6.25 |
| 20 g HG added | 5.54 | 0.78 | 5.58 | 2.72 | 0.57 | 560.25 | 73.20 | 38.30 | 5.30 |
| 30 g HG added | 5.68 | 0.79 | 7.16 | 2.25 | 0.59 | 559.70 | 75.75 | 42.55 | 5.00 |
| Soil culture | 6.03 | 0.96 | 4.44 | 2.55 | 0.43 | 723.10 | 163.85 | 195.20 | 12.20 |

* Based on dry weight.

**Table 26. Nutritional content of the edible parts of small paitsai from different treatments of nutriculture and farmer soil culture**

| Treatment | Protein (%) * | Fiber (%) * | Carotene (mg/100g) ** | Vitamin C (mg/100g) ** | Chlorophyll (mg/100g) ** | Sucrose (mg/100g) ** | Starch (mg/100g) ** |
|---|---|---|---|---|---|---|---|
| No HG (check) | 36.83 | 12.41 | 0.870 | 20.78 | 0.15 | Trace | Trace |
| 10 g HG added | 37.03 | 12.52 | 1.505 | 25.10 | 0.24 | Trace | Trace |
| 20 g HG added | 36.34 | 12.00 | 1.640 | 23.86 | 0.21 | Trace | Trace |
| 30 g HG added | 37.28 | 12.29 | 1.655 | 23.48 | 0.23 | Trace | Trace |
| Soil culture | 38.15 | 11.45 | 0.940 | 29.89 | 0.13 | Trace | Trace |

* Based on dry weight.
** Based on fresh weight.

# *Plant Pathology*

## Evaluation of Sugarcane Varieties for Resistance to Major Diseases

1. Downy mildew (*Peronosclerospora sacchari*)

In 1992 a total of 206 clones selected at TSRI and 25 varieties from Hawaii, Mauritius, and Fiji were tested for their resistance to downy mildew at the Nantou nursery. Infection was allowed to occur naturally. Scanty rainfall from July to September of 1992 caused a very low incidence of downy mildew on both tested and standard varieties. However, moderate to high levels of resistance to the disease were found in 87% of the new clones (Table 27). Among the foreign varieties tested, only H78-3599 and R568 showed high susceptibility to the disease.

2. Smut (*Ustilago scitaminea*)

In autumn and spring trials at Shihchungshi nursery 154 TSRI clones and 31 foreign varieties were tested for resistance to smut (Race 1) using the pin-pricking method. Most of Hawaiian varieties and 60.4% of the new clones were moderately to highly resistant to the disease. Of the foreign varieties tested, M198/71 and R568 showed high susceptibility (Table 28).

3. Leaf blight (*Leptospheria taiwanensis*) and leaf scorch (*Stagonospora sacchari*)

The reactions of 26 promising clones and 18 foreign varieties to leaf blight and leaf scorch were tested at Tainan. Five clones (84-8722, 86-3156, 86-3192, 86-4526,

**Table 27. Response of new clones and foreign varieties to downy mildew**

| Level of resistance | No. of varieties tested | | | Standard varieties | |
|---|---|---|---|---|---|
| | Taiwan | Hawaii | Mauritius | Variety | Infection (%) |
| Resistant | 92 | 6 | 2 | NCo310 | 2.5 |
| Moderate | 87 | 5 | 3 | F134 | 4.5 |
| Susceptible | 27 | 2 | 1 | PT43-52 | 23.7 |

**Table 28. Response of new clones and foreign varieties to smut (Race 1)**

| Level of resistance | No. of varieties tested | | | Infection of standard varieties (%) | | |
|---|---|---|---|---|---|---|
| | Taiwan | Hawaii | Mauritius | Variety | Autumn | Spring |
| Resistant | 69 | 15 | 3 | F178 | 15.5 | 21.4 |
| Moderate | 24 | 2 | 1 | F160 | 28.7 | 70.4 |
| Susceptible | 61 | 0 | 2 | NCo310 | 95.9 | 96.0 |

and 86-7074) and six Fijian varieties (LF79-1142, LF80-206, LF80-226, LF80-227, LF80-352, and LF80-354) showed a hypersensitive reaction to leaf blight. Most of the other clones and varieties tested were moderate to resistant to leaf scorch.

4. Common rust (*Puccinea melanocephala*) and orange rust (*P. kuehnii*)

Surveys were made to determine the responses of 106 promising clones to the rust diseases in the T4 and T5 regional tests at six locations. Because the rainfall from January to June 1992 was 1.2 times greater than average, the incidence of the two rust diseases, especially common rust, was very low in the field. Orange rust was observed on 23 clones (21.7%), of which seven clones were susceptible. Only eight clones (7.5%) were infected by common rust; three were susceptible and five were moderate. Only two clones were infected by both rust diseases.

5. Quarantine

A total of 39 sugarcane varieties were introduced (11 from Mauritius, 20 from Fiji, and 8 from Fuchien, PRC) between July 1992 and June 1993. Six varieties from Mauritius and five from Fiji failed to germinate at the quarantine nursery. The remaining varieties did not show any systemic disease symptoms up to August 1993. (C. S. Lee and J. G. Fang)

## Effect of Smut Disease on Sugarcane Yield

The effect of smut disease on sugarcane yield was determined in a smut-infected ROC11 ratoon cane field at Nanchou Sugar

**Table 29. The effect of smut disease on sugar yield**

| Items | Healthy cane | Diseased cane | Percent affected |
|---|---|---|---|
| Stalk length (cm) | 155.6 | 152.3 | - 2.1 |
| Stalk diameter (cm) | 2.4 | 2.2 | - 8.3 |
| Stalk weight (g) | 875.6 | 678.2 ** | -18.8 |
| No. stalks / stool | 5.7 | 6.1 | + 7.0 |
| Stool weight (kg) | 4.63 | 4.26 | - 8.0 |
| E. S. G. / stool (%) | 14.02 | 14.25 | + 1.6 |
| Sugar / stool (g) | 670.0 | 601.5 | -10.2 |
| Sugar / stalk (g) | 117.5 | 96.8 ** | -17.6 |

** Significant at 1% level by t-test.

Mill in March 1992. Thirty stools each of healthy and diseased cane were randomly collected. All cane stalks were cut by hand at ground level, topped above the last hard stalk internode, and stripped of all leaves and leaf sheaths. Then the stalk diameter and stalk length of each were measured. Each stool was weighed and percent of available sugar (E. S. G.) was estimated.

The results indicate that smut infection significantly reduced cane yield by decreasing both stalk diameter and stalk length (Table 29). Though the stalk number and sugar content of affected stools were a little higher than normal, the sugar yield per stalk was significantly decreased. (C. S. Lee and J. G. Fang)

### Variation of *Xylaria* cf *warburgii*

Sixteen isolates of *Xylaria* cf *warburgii*, a causal organism of root and basal stem rot of sugarcane, were obtained from fields of four TSC farms. Mycelia of the isolates were paired in all combinations on oatmeal agar medium, and the pairings were observed for compatibility. Among the 4, 5, 2, and 5 isolates from Chishan, Mayuan, Tapumai, and Yuching, respectively, one, three, two, and four vegetative compatibility (v–c) groups, respectively, were recognized. All pairs consisting of isolates from different fields were incompatible. Polyacrylamide gel electrophoresis was employed to compare the patterns of native mycelial proteins from two v–c groups isolated from Tapumai sugarcane fields. Two distinct protein patterns were formed (Fig. 22). The results obtained with electrophoresis support the use of v–c groups as an aid in distinguishing the variation of *X.* cf *warburgii*. The data also demonstrate that the field population of *X.* cf *warburgii* is genetically diverse. (J. G. Fang and C. S. Lee)

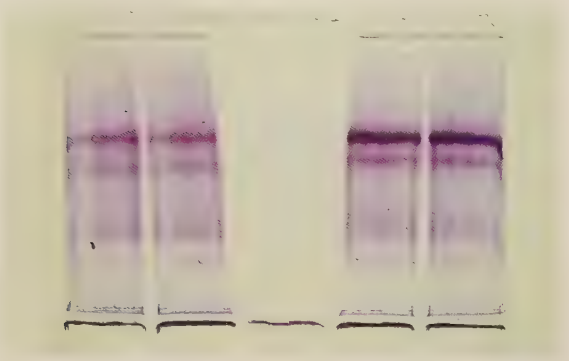


Fig. 22. Protein profiles for two v-c groups of *Xylaria* cf *warburgii* isolated from Tapumai as differentated by electrophoresis of native mycelial proteins.

### Cormlet Formation of Gladiolus in Tissue Culture

Shoots of gladiolus (*Gladiolus hortulanus* cv. Black Bone) initiated from meristem tips were cultured on solid medium containing MS+kinetin (4 mg/l). For in vitro cormlet formation, gibberillic acid inhibitors (abscisic acid and ancymidol) were combined with 3% or 6% sucrose and tested. Four weeks after cultivation, the number and size of the cormlets and the vigor of plants were examined. As shown in Table 30, 6% sucrose induced more cormlets than 3% sucrose, but reduced the vigor of plants. Abscisic acid increased the number of cormlets significantly, but the size and number were reduced at higher concentrations. In this experiment, MS+0.2 mg/l abscisic acid offered the best results; the test plants produced vigorous growth and more large cormlets; whereas, ancymidol inhibited the formation of cormlets and slightly reduced the vigor of the gladiolus. (Y. G. Liang and C. T. Chen)

### Micropropagation of Disease-Indexed Badila Cane by Shoot Tip Culture

Rapid multiplication of disease-indexed Badila cane was developed by shoot tip culture. The mother stocks of Badila cane plants, devoid of sugarcane mosaic virus (SCMV) and *Clavibacter xyli* subsp. *xyli*, were maintained in the greenhouse and used for micropropagation. Shoot tip tissues of

**Table 30. The effect of ABA and ancymidol combined with different sucrose content on the cormlet formation of gladiolus***

| Medium | | 3% Sucrose | | | 6% Sucrose | | |
|---|---|---|---|---|---|---|---|
| | | Size | Number | Growth | Size | Number | Growth |
| MS+ABA | 0.2 mg/l | L | 68 | II | L | 70 | II |
| | 0.5 mg/l | M | 52 | III | S | 60 | IV |
| | 1.0 mg/l | S | 41 | IV | S | 31 | IV |
| | 2.0 mg/l | S | 28 | IV | S | 25 | IV |
| MS+Ancymidol | 0.1 mg/l | S | 2 | II | M | 4 | II |
| | 0.2 mg/l | S | 3 | II | S | 5 | II |
| | 0.5 mg/l | S | 5 | II | M | 6 | II |
| | 1.0 mg/l | M | 4 | II | S | 3 | II |
| MS | | L | 29 | I | L | 36 | II |

* Size: diameter of cormlet. L: > 0.8 cm, M: 0.4–0.8 cm, S: < 0.4 cm.
Growth: vigor determined by the width and length of leaves.
I: best II: good III: poor IV: poorest.

the above two disease-indexed cuttings, approximately 0.5 to 0.7 cm in length, were put into MP II liquid medium after sterilization with 3% hypochlorite solution. After 4 to 6 weeks, the shoot tip cultures were established. The cultures were dissected and transferred into MP II medium again and divided four times for shoot multiplication (Fig. 23). The number of shoots increased tenfold within 2 weeks. The shoots were then rooted in the MPVI medium that we developed and which contained 60g/l sucrose, vermiculite, and active carbon (Fig. 24). A

Fig. 23. Multiplication of shoots in liquid medium.

Fig. 24. Rooting of shoots in MPVI medium.

great number of plantlets, between 120,000 and 140,000 or three to four shoots per tube, were obtained during 5 to 6 months of micropropagation. After acclimation for 3 to 5 months, the young cane plantlets were from 25 to 30 cm high, and ready for planting. There were enough plantlets from one shoot to plant one hectare. (C. T. Chen, Y. G. Liang and P. H. Jiang)

### Cloned DNA Probes for RSD Agent

EcoRI restriction fragments of genomic DNA from *Clavibacter xyli* subsp. *xyli* (CXX) were ligated with plasmid pUC18 and cloned in *Escherichia coli* JM109. The cloned DNA inserts from recombinant plasmids were EcoRI-excised, labeled with nonradioactive digosigenin, and used as probes. Ten specific DNA probes (RSD3, 15, 30, 31, 32, 35, 37, 41, 71, and 73) were selected for disease detection and pathogen differentiation. In the specificity tests, all of the ten CXX DNA probes specifically differentiated *Clavibacter xyli* from the other bacteria. Seven out of the ten CXX probes cross-reacted with *C. x.* subsp. *cynodontis* (CXC) very weakly under moderate stringency wash conditions of hybridization. In the sensitivity tests, all ten DNA probes detected the homologous DNA of CXX from 0.19 to 0.75 ng. The DNA probes effectively detected the various cell numbers of CXX from $10^4$ to $10^5$ /ml. In Southern hybridizations, distinctly different band patterns were shown when the probes hybridized with DNA from CXX and CXC. Among these probes, RSD3, 15, 30, 31, 37, and 71 efficiently detected CXX present in the sap collected from symptomless sugarcane. (C. H. Chung, C. P. Lin and C. T. Chen)

## *Entomology*

### Attractiveness of Synthetic Sex Pheromones to Sugarcane Insects

Three synthetic sex pheromone compounds, (Z)−9-dodecenyl acetate, (E)−7, 9-decadienyl acetate, and (E)−9, 11-dodecadienyl acetate, offered by Shin-Etsu Chemical Company were tested for their attractiveness in the field to the sugarcane gray borer, *Argyroploce schistaceana* Snellen. The most satisfactory results were obtained from the mixture of the above components at a ratio of 10:3:1. From 10 April to 9 August 1992, an average of 8.7 male adults were captured in the traps baited with the pheromones; while, an average of 9.0 males were caught in those baited with two virgin females. From 7 December 1992 to 8 April 1993, averages of 3.7 and 2.3 male moths were caught in pheromone and virgin female traps, respectively (Table 31). Unlike the pheromone which showed persistent effectiveness throughout the 120 days, the virgin females had to be replaced 38 and 36 times during the same time period.

The synthetic sex pheromone (Z)−11-hexadecenol was also tested for its attractiveness to the sugarcane shoot borer, *Chilotraea infuscatella* (Snellen) Kapur. Sticky traps consisting of 5−cm plastic tubes with 0.6 mm internal diameter were each baited with 13 mg of the sex pheromone and placed at 0.2 m, 1 m, and 2 m heights in cane fields. In a maturing cane field, significantly more males were captured in the 0.2−m−high traps (daily average of 1.60 males/trap) than in the 1−m and 2−m−high traps (daily average of 0.20 and 0.43 males/trap, respectively). In a seedling cane field, averages of 0.90, 0.55, and 0.10 males were caught at 0.2 m, 1 m, and 2 m, respectively. When different pheromone dosages were tested, the largest catch of 1.63 males was recorded in the traps fixed with baits containing 2 mg of the sex pheromone (Table 32). (W. Y. Cheng and S. M. Chen)

### Nonpartition Rearing of the Lacewing, *Mallada basalis*

A 2,513-$cm^3$ glass container into which eggs of *Corcyra cephalonica* were supplied

**Table 31. Trapping of male sugarcane gray borer moths with virgin females and synthetic sex pheromones****

| Bait | No. males/trap/day during different time periods | | | | | No. of times females replaced |
|---|---|---|---|---|---|---|
| | 1–30 days | 31–60 days | 61–90 days | 91–120 days | average | |
| | | | 10 April to 9 August 1992 | | | |
| Pheromones | 11.4±1.3* | 9.2±0.9 | 10.8±1.1 | 4.1±0.5 | 8.7±0.5 | – |
| 2 ♀♀ | 8.4±1.0 | 8.8±1.1 | 13.1±1.4 | 6.5±1.1* | 9.0±0.6 | 38 |
| | | | 12 December 1992 to 8 April 1993 | | | |
| Pheromones | 7.6±0.5* | 2.2±0.5* | 3.4±0.4* | 1.6±0.2 | 3.7±0.3* | – |
| 2 ♀♀ | 4.2±0.5 | 1.1±0.3 | 1.7±0.3 | 2.3±0.3 | 2.3±0.2 | 36 |

* Significantly different at 5% level by t-test.
** (Z)-9-dodecenyl acetate: (E)-7, 9-decadienyl acetate: (E)-9, 11-dodecadienyl acetate = 10:3:1.

**Table 32. Trapping of *Chilotraea infuscatella* male moths with various dosages of synthetic sex pheromone**

| Dosage (mg) | No. observed** | No. males/trap/day* |
|---|---|---|
| 13 | 30 | 0.90±0.15b |
| 5 | 30 | 1.10±0.19ab |
| 2 | 30 | 1.63±0.30a |
| 1 | 30 | 1.47±0.24ab |
| 0.6 | 30 | 1.07±0.23ab |

* Means followed by the same letter are not significantly different at the 5% level by Duncan's multiple range test.
** From 14 to 30 April 1993.

three times was used in nonpartition rearing of the lacewing, *Mallada basalis* (Walker). The containers had eight pieces of corrugated paper strips, 16–19 cm × 2.3–2.5 cm, placed in three layers. A piece of polyethylene wrap with many tiny holes was used to cover the container so it could be opened easily and recovered quickly when refilling with host eggs. Pupation of 85.0–99.2% and emergence of 86.8–97.7% were observed, and 98.2–99.4% of the pupae were recovered from inside the tunnels of the corrugated paper strips (Fig. 25). But only 63.9% were suc-

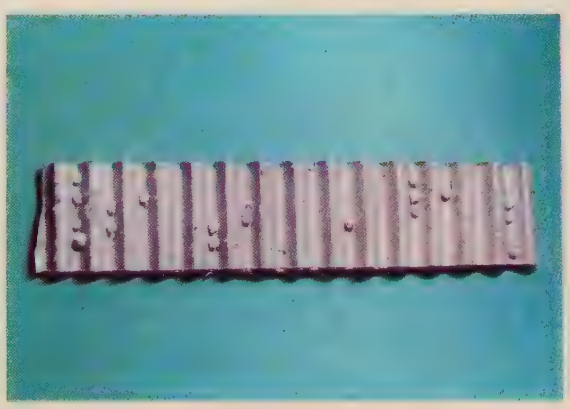


Fig. 25. *Mallada basalis* were found pupated inside the corrugated paper strips.

**Table 33. Mass rearing of the larvae of *Mallada basalis****

| Container | Pupation (%) | Emergence (%) | Reared (%) | Sex ratio (♀♀ : ♂♂) |
|---|---|---|---|---|
| A | 97.9 | 80.3 | 78.6 | 1.2:1 |
| B | 82.5 | 87.4 | 72.1 | 1.1:1 |
| C | 78.7 | 83.9 | 66.0 | 1.2:1 |
| Average | 86.4 | 83.6 | 72.2 | 1.1:1 |

* Rearing of 1000 lacewings in 18-liter plastic pans.

cessfully reared if the glass vessel contained no corrugated paper strips. The processes were applied to the mass rearing of 1000 *M. basalis* with 50 ml of *Corcyra* eggs in an 18-liter plastic pan. Average results of 86.4% pupation and 83.6% emergence were obtained (Table 33). (S. M. Chen and W. Y. Cheng)

### Field Trials on the Susceptibility of Sugarcane Varieties and Clone to Sugarcane Woolly Aphid

Five sugarcane varieties (F160, ROC1, ROC10, ROC16, and ROC17) and one clone (82-2825) were tested for their response to the woolly aphid, *Ceratovacuna lanigera,* in autumn-planted cane fields for four crop years. However, ROC16 and ROC17 were not tested in the 1992-1993 and 1989-1990 crop years, respectively. The investigations on the occurrence of woolly aphid on the tested varieties and the clone were made twice a month and began either in late December of the year of planting or in early January of the next year. A sample of nine plants were randomly taken from each plot. The leaves of each plant were thoroughly examined and the levels of aphid infestation were classified into following categories.

0: no aphids
1: with few nymphs or adults
2: aphid colonies covering 1/4 of the leaf area
3: aphid colonies covering 1/3 of the leaf area
4: aphid colonies covering 1/2 of the leaf area
5: aphid colonies covering entire leaf area

Percent of aphid infestation was then calculated according to the method described by Townsend and Heuberger (1943).

The occurrence of woolly aphid in a year could be divided into three stages: early (December to January), middle (February to March), and peak (April to May). The infestation percentages were not significantly different among varieties and the clone during the early to early middle stages. However, significant differences started to appear during the late middle stage. The woolly aphid infestation was more severe in the crop years 1989-1990 and 1992-1993 than in the crop years 1990-1991 and 1991-1992. The highest infestation percentages for the tested varieties and clone in these four crop years were as follows: F160 42.5%, ROC1 24.6%, ROC10 34.8%, ROC16 44.6%, ROC17 12.1%, and 82-2825 63.8%. The results showed that the varieties ROC16, F160, ROC10, and clone 82-2825 were more susceptible to woolly aphid than varieties ROC1 and ROC17. Throughout the testing period, ROC17, especially, showed low infestation and good growth. (S. L. Yang, C. H. Juan and S. M. Tsai)

## Studies on Entomogenous Nematodes

A cubic bio-formulated granule containing an entomogenous nematode (*Steinernema carpocapsae, Rhabditis terricola,* or *Rhabditis* sp.) (Fig. 26) was made of bagasse and other materials. The granule was placed in plastic bags or in soil and stored at 6°C or at room temperature (22–26°C). The survival rates of the nematodes were determined periodically. All three types of nematodes survived over a 1-month period regardless of temperature or location of storage (Table 34). However, the highest survival rate was found in the nematodes stored in the soil at room temperature. (Z. N. Wang, S. M. Tsai and W. F. Yee)

Fig. 26. A bio-formulation of entomogenous nematode.

## Rat Control

A male *Rattus losea* tagged with a RT collar and SM1 transmitter from AVM Instrument Co., USA, was released into a cane field to study its movement and activity. After the sugarcane was harvested, the tagged rat moved into nearby brush, feeding on weeds and cane remnants. One week later it moved about 325 m northward to another unharvested cane field and caused some damage there. When the later habitat was harvested, this tagged rat was found buried under the base of a cane stool and died shortly after being dug out.

*Bandicota nemorivaga, R. losea,* and *Apodemus agrarius* have been successfully propagated in the laboratory in the last three years. The reproduction period lasted from 5 to 13 months for *B. nemorivaga.* Both *R. losea* and *A. agrarius* have shown high fertility rates. The pregnancy intervals for these three species were found to be 44.9, 33.7, and approximately 30 days, respectively (Table 35). The shortest in-

**Table 34. Survival percentage of three entomogenous nematodes in bio-formulations***

| Days after formulation | *S. carpocapsae* | | | *R. terricola* | | | *Rhabditis* sp. | | |
|---|---|---|---|---|---|---|---|---|---|
| | A | B | C | A | B | C | A | B | C |
| 1 | 89.9 | 83.5 | 92.7 | 89.5 | 87.9 | 91.3 | 90.7 | 89.2 | 91.0 |
| 3 | 77.6 | 76.5 | 90.1 | 79.3 | 76.2 | 86.3 | 83.9 | 74.3 | 84.8 |
| 7 | 67.1 | 64.5 | 80.3 | 67.8 | 60.0 | 79.5 | 71.8 | 65.6 | 76.6 |
| 14 | 61.8 | 53.6 | 71.8 | 64.0 | 55.6 | 70.0 | 70.3 | 64.2 | 71.0 |
| 21 | 55.4 | 50.0 | 62.3 | 61.4 | 51.4 | 67.4 | 61.9 | 59.7 | 69.2 |
| 30 | 43.2 | 40.0 | 59.2 | 57.8 | 47.1 | 58.0 | 53.2 | 52.7 | 63.8 |

* A: Bio-formulation put in bag and stored at 6°C.
B: Bio-formulation put in bag and stored at room temperature.
C: Bio-formulation put in soil and stored at room temperature.

**Table 35. Propagation of three wild rat species in the laboratory**

| Species | Litters obtained* | Progenies produced | Progenies/ litter | Interval between litter (days) |
|---|---|---|---|---|
| *Bandicota nemorivaga* | 56(7) | 170 | 3.5 | 44.9 |
| *Rattus losea* | 30(1) | 185 | 6.4 | 33.7 |
| *Apodemus agrarius* | 49(4) | 153 | 3.4 | – |

* Data in parenthesis are the number of litters that failed.

tervals observed were 26, 23, 21 days, respectively. Furthermore, the pregnant females averaged 3.5, 6.4, and 3.4 young per litter for these three species, respectively. (P. Y. Wang)

# *Sugar Technology*

### Development of a Control System for Multiple-Effect Evaporators

Juice concentration is generally done in multiple-effect evaporators to improve steam economy. The evaporation station in a raw sugar factory typically removes about 60% of the water from the clarified juice, increasing the solid content from about 12 Brix to about 62–67 Brix.

A control system for multiple-effect evaporators was designed which handles the following major control variables: liquid feed rate, steam input to the first effect, evaporator liquid level, product liquor Brix, and last effect absolute pressure. Steam pressure at the first effect evaporator (Kestner type) was controlled by the liquid feed rate to the first effect and the product syrup Brix. Liquid flow rate was controlled mainly by a flow controller receiving its set point from the feed tank level. The liquid level of the sealed downtake calandria evaporators was sensed by a differential pressure transmitter and regulated by the bodies' liquid feed valve. Syrup Brix was sensed by

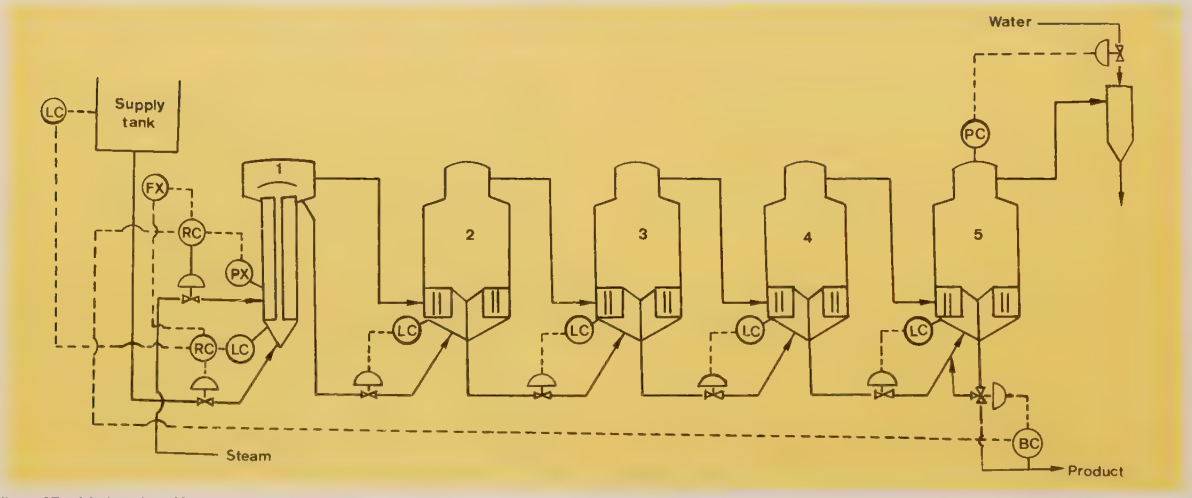



Fig. 27. Multiple-effect evaporation control system.

a differential pressure transmitter with a remote seal diaphragm and regulated by recirculation to the last effect. Absolute pressure at the last effect was sensed by an absolute pressure transmitter and regulated by the flow of cooling water to the barometric condenser. Fig. 27 is the control diagram for multiple-effect evaporators.

A control program was constructed with the GENESIS control software package. Sequence and loop control allowed the entire operation to operate automatically. A complete evaporation cycle was divided into the three steps of warm-up, run, and stop.

This control system had already been set up in a sugar factory in the 1992–93 crop year. The factory evaluation report shows improved stabilities of syrup Brix and liquid level in the evaporators. (Y. C. Hsiao, C. H. Chen, S. P. Hu and C. H. Jen)

### Improvement of a Control Program for the Sugar Crystallization Process

A control program for the crystallization process has been constructed with the GENESIS control software package. It ran successfully during the milling season of 1992–93 at Hualien and Kaohsiung sugar mills. Yet, because the third massecuite is very viscous, the massecuite sometimes has a harmful effect on sugar recovery, boiling time, and other operating conditions. To solve this problem, we developed a process allowing either continuous or intermittent feeding at the boiling step. An operator at the system monitor chooses the feeding method with a single button. This initiates the appropriate control loops so that the molasses valves, balance water valves, and feeding time are adjusted automatically.

The results showed that the recovery and quality of sugar was best when using the intermittent feeding method. (F. Y. Liu and J. C. Lin)

### Biological Treatment of Wastewater from a Sugar Factory by a Facultative-Aerobic System

Simulated sugar factory wastewater was treated by a facultative-aerobic system. In this system, anaerobic and aerobic bacteria decomposed sucrose waste through reduction and oxidation processes, respectively, and produced organic acids, methane, carbon dioxide, water, and energy. A study was first conducted using a high chemical oxygen demand (COD) concentration wastewater of 10,000 mg/l under the total hydraulic retention time (HRT) of 15.6 days. COD, biological oxygen demand (BOD) and suspension solid (SS) in the effluent were 153, 8, and 40 mg/l, respectively. Initial wastewater of 5,000 mg/l treated under the same conditions resulted in COD 88 mg/l, BOD 41 mg/l, and SS 40 mg/l in the effluent. However, an HRT of only 6.4 days was needed for the treatment of low COD concentration wastewater of 2,000 mg/l to give COD 117 mg/l and SS 30 mg/l in the effluent.

Originally, the synthetic wastewater was colorless and odorless; and its pH was about 7. During sucrose decomposition, the pH of the wastewater in the facultative tanks dropped to 3.5–5 due to organic acids produced by anaerobic bacteria. The color of the wastewater became milky white, concurrently. Finally, the organic acids in the wastewater were completely decomposed in the aerobic tanks through aerobic digestion. Therefore, the sour odor of organic acids in the wastewater gradually declined and then disappeared. At the same time, the pH of the wastewater in the aerobic tanks gradually increased to 5.8. After sedimentation of sludge, the odorless effluent which had a pH of 6 or higher could be safely released.

A full-scale facultative-aerobic system with a working volume of 3,000 $m^3$ was built at Peikang sugar refinery to treat its waste-

water. The system worked as expected. The results were similar to those reported above. (C. M. Huang, W. C. Chen, S. W. Li, L. H. Wang, H. K. Sheen and C. H. Chen)

### Determination of the Polarization of Sugars (A and B Grade White Crystal and Raw Sugar) with Aluminium Sulfate-Calcium Carbonate Reagent

In the future, the analytical use of toxic clarification agents containing lead during sugar production will have to be abandoned. Some alternative reagents have been sought for the determination of polarization (Pol) of sugars, one of which is aluminium sulfate-calcium carbonate.

The optimum ratio of aluminium sulfate to calcium carbonate was found to be about 3:4, and clarification of 100 ml of sugar solution (26 g/100 ml) required about 4 g of the reagent. The filtrate was clear and the filtration rate was more rapid than when using the dry lead acetate reagent.

Because of the excellent correlation between the two methods, a regression equation of $Pol_{lead\ acetate} = 0.9965 * Pol_{aluminium\ sulfate} + 0.6045$ may be used to convert the pol reading from the aluminium sulfate – calcium carbonate clarified sugar solution to the reading of the familiar lead subacetate method. The standard error of estimation was 0.039; it was extremely low. The new method could be applied to routine analyses in sugars. (H. I. Shiue)

## *Biotechnology*

### Isolation of Phytase Producing Microorganisms

To reduce the need for phosphate additives in animal feeds and to decrease phosphate pollution induced by animal excretions, a source of the enzyme phytase is needed for use in animal feeds. The enzyme would release phosphate from phytin which is found abundantly in most feeds but which can not be used by animals.

*Aspergillus ficcum, Aspergillus terreus, Bacillus subtilis* natto, and other microorganisms isolated from soils and organic materials were screened for phytase production. Both liquid shaking culture and semisolid culture with rice bran or wheat bran were used for screening. Among them, maximum phytase production was found in a semisolid rice bran culture of the mutant of *Aspergillus ficcum*, NRRL 3135. Eight u/g of substrate corresponded to about 40 u/g of Sigma product. Work to improve the enzyme production method will be continued. (Y. C. Kuo and Y. T. Liu)

### Separation and Purification of 5′-Uridine Monophosphate from a Dark Brown Solution

Several types of flocculants have been investigated for removing color and impurities in a dark brown solution of 5′-uridine monophosphate (5′-UMP). A simple and inexpensive pretreatment of the 5′-UMP solution has been developed to remove 51% of the total impurities and up to 98% of the color.

We are still looking for economical and effective methods of producing pure 5′-monophosphate nucleotides on a pilot plant scale. (P. W. Yang and S. L. Huang)

### Production of $\beta$-Cyclodextrin and Coupling Sugar by Cyclodextrin Glucanotransferase

Cyclodextrin glucanotransferase ($\alpha$-1,4-glucan 4-glycosyltransferase, EC. 2.4.1.19, CGTase) with multiple reaction mechanisms is a vital enzyme to generate cyclodextrins, malto-oligosaccharides, and coupling sugar.

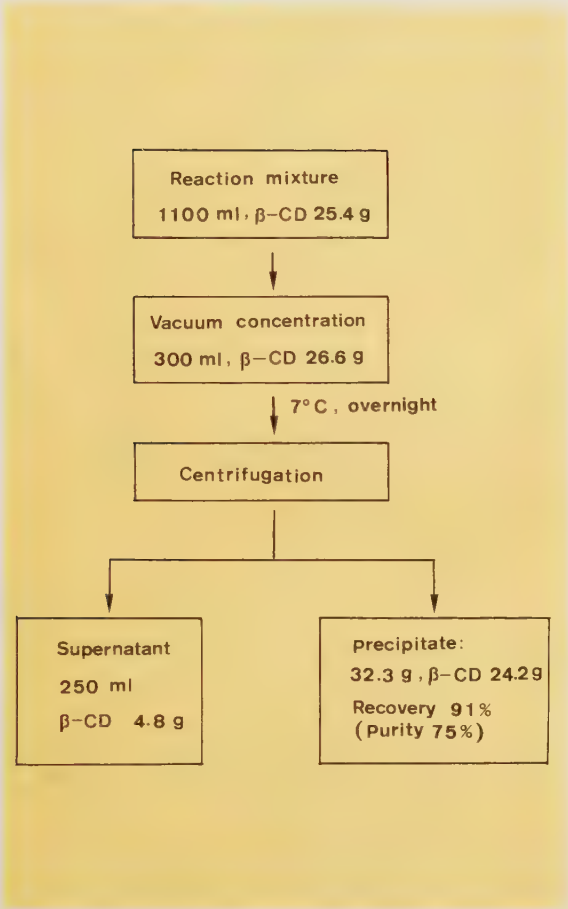



Fig. 28. β-CD purification by one-step precipitation.

A strain of alkalophilic *Bacillus* sp., No. 35, producing CGTase has been successfully isolated. When incubated at 37°C with an aeration rate of 1.0 vvm and an agitation rate of 300 rpm ($K_La = 6\ min^{-1}$) for 35 hours, the strain produced 3.5 u/ml CGTase activity in a 14-l jar fermentor. The stability of CGTase produced by strain No.35 is acceptable. The CGTase activity remained 95% after the crude enzyme broth was stored at 4–9°C for 140 days without any pretreatment. Thus the enzyme can be stored and transported easily. The optimal conditions for β-cyclodextrin (β-CD) production with the produced crude CGTase were investigated by the Taguchi orthogonal methods. Under suitable conditions, 6% β-CD was synthesized in the reaction mixture. The purification of β-CD was carried out with a one-step precipitation yielding 91% recovery of β-CD with 75% purity (Fig. 28). The production of coupling sugar by the same crude CGTase was also investigated. The preliminary results showed that a 56% coupling sugar conversion was obtained after 24 hours (Fig. 29). (P. L. Chen, C. Y. Chang and Y. T. Liu)

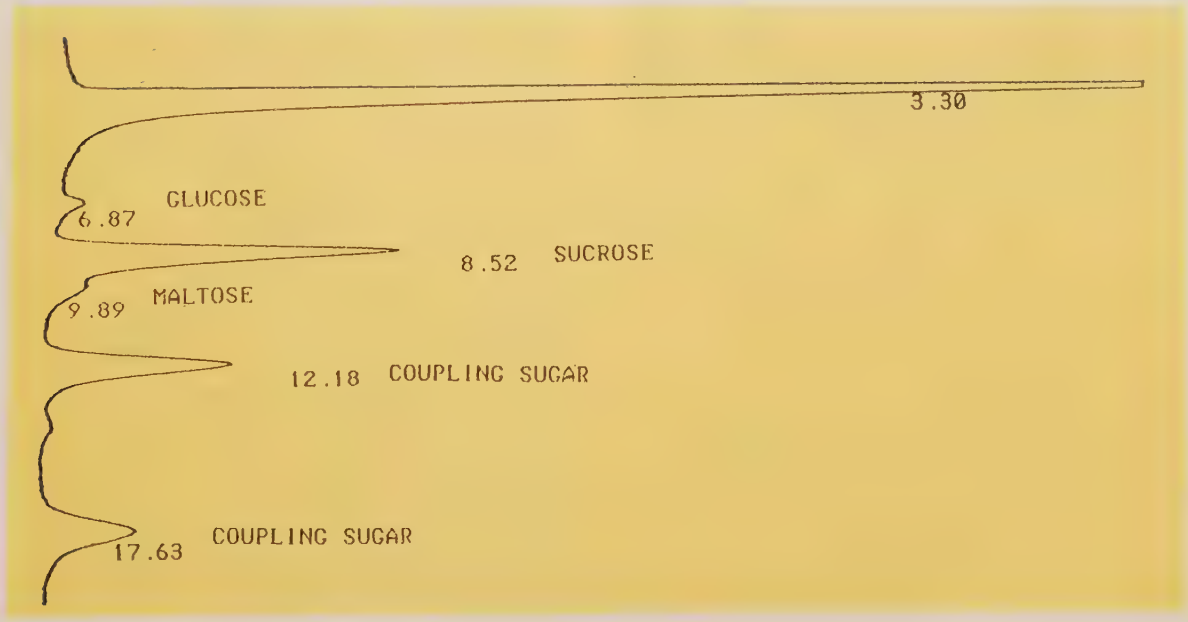



Fig. 29. HPLC analysis chart of coupling sugar.

### Making Gypsum Flake Board with Bagasse

Since gypsum fiber board, a completely fireproof material, was developed in Germany, it has been widely used in modern building construction.

Paper-facing gypsum board is commercially produced in Taiwan but still in small quantity. We used bagasse instead of waste paper fiber to make gypsum bagasse flake board (Fig. 30) and found that the strength of the board was better than the commercial paper-facing gypsum board (Table 36). The fireproof properties of the flake board are good and the manufacturing cost is much lower than that of paper-facing gypsum board. (Y. Y. Cheng, W. F. Yee and Y. T. Liu)

Fig. 30. Gypsum bagasse flake board.

### Ethanol Fermentation with Refinery Final Molasses

Refinery final molasses contains high sugar, up to 67% (w/v). It would be a good source for ethanol fermentation, but upon examination it was revealed that the fermentation efficiency was low (62%) because of its poor nutrition.

To improve the fermentation efficiency, additions of yeast extract, alcohol distillery slops, ammonium sulfate, and rice bran were tried. Among them, 0.5% addition of yeast extract gave the highest efficiency, up to 90%. Alcohol distillery slops and yeast extract were similar in effectiveness. Appropriate combinations of refinery final molasses and defecation process molasses gave favorable results without any nutrient enrichment (Table 37).

The decolorizing agent, QAS, and the flocculent, A-110, were used in the sugar refining process. The effects of these two agents in ethanol fermentation were assayed, and they were found to cause no

**Table 36. The properties of five types of gypsum board**

| Category of gypsum board | Density ($g/cm^3$) | Thickness (cm) | Strength ($kg/cm^2$) |
|---|---|---|---|
| Paper-facing gypsum board (Taiwan) | 0.76 | 1.2 | 50.7 |
| Gypsum bagasse flake board (No. 21) | 0.91 | 1.2 | 56.2 |
| Gypsum bagasse flake board (No. 45) | 0.96 | 1.2 | 50.4 |
| Gypsum fiber board (USA) | 0.97 | 1.3 | 51.8 |
| Gypsum fiber board (Germany) | 1.40 | 1.0 | 59.2 |

**Table 37. Ethanol fermentation resulting from combination of refinery final molasses and defecation process molasses (Total sugar 18% w/v)**

| Ratio of molasses used | | | Total sugar (% w/v) | Ethanol conc. (% v/v) | Fermentation efficiency % |
|---|---|---|---|---|---|
| Defecation process | : | Refinery | | | |
| 100 | : | 0 | 17.70 | 8.88 | 77.90 |
| 92.79 | : | 7.21 | 17.83 | 9.10 | 79.25 |
| 85.12 | : | 14.88 | 17.95 | 9.33 | 80.71 |
| 76.94 | : | 23.06 | 18.08 | 9.53 | 81.84 |
| 68.20 | : | 31.80 | 18.20 | 9.77 | 83.35 |
| 58.84 | : | 41.16 | 18.33 | 9.96 | 84.37 |
| 48.80 | : | 51.20 | 18.46 | 10.11 | 85.40 |
| 38.00 | : | 61.00 | 18.58 | 10.38 | 86.74 |
| 26.33 | : | 73.67 | 18.71 | 10.46 | 86.81 |
| 13.71 | : | 86.29 | 18.83 | 10.26 | 84.60 |

problems during the fermentation. (M. C. Hsie)

### L-Lysine Production by *Brevibacterium* sp. P1–13 with Raw Sugar Medium

The culture conditions for L-lysine production by *Brevibacterium* sp. P1–13 in a raw sugar medium were investigated with a 5–1 jar fermentor. The addition of DL-isoleucine to the main medium enhanced cell growth and shortened the lag phase. After thorough investigation of medium composition and culture conditions a 10% L-lysine · HCl solution was produced within 35 hrs with a yield of 50% based on total sugar input (Fig. 31). (J. S. Wang, W. L. Cheng, C. C. Chang and Y. T. Liu)

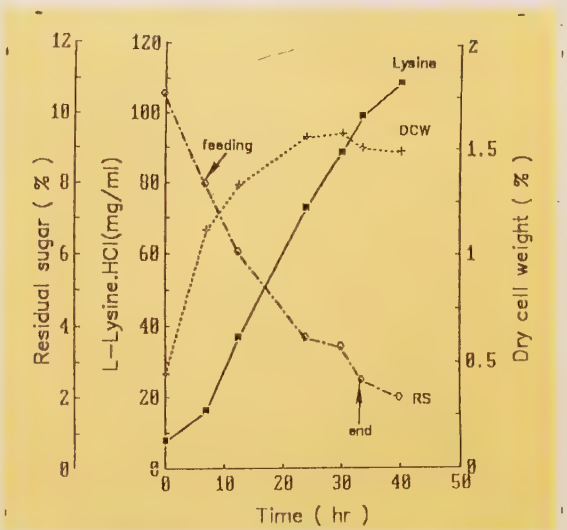



Fig. 31. Time course of L-lysine fermentation with molasses (TS 5%) and raw sugar (TS 17%) medium by P1–13 strain.

# Research Projects in Progress

## Plant Breeding

1. Breeding of superior sugarcane varieties.
2. Breeding of economic crops.
3. Evaluation of the genetic merits of sugarcane germplasm and parental varieties.
4. Breeding of sugarcane for beverages.
5. Rapid propagation of anthurium using the tissue culture method.

## Agronomy

1. Weed management in sugarcane fields.
2. Responses of new sugarcane varieties to water deficiency.
3. Rapid production of compost and wastewater treatment.
4. Land treatment of organic wastewater with subsurface drainage.
5. Surge flow furrow irrigation with an underground pipeline system.
6. Microcomputer processing of water well data.
7. Improvement of sugarcane harvester and billet planter.
8. Application of AUSCANE model in sugarcane fields of Taiwan.
9. Movement and adsorption of heavy metals in soil irrigated with pig waste.
10. Development and application of an information system for TSC land resources.

## Horticulture

1. Breeding of *Phalaenopsis* .
2. Commercial production of *Phalaenopsis*. (1) Regulation of flower period, preservation of cut flowers, and treatment of seedlings during shipping, (2) Irrigation method on the moving bench of the automated greenhouse.
3. Control of diseases and insect pests of the *Phalaenopsis*.
4. Automatic environmental control for the production of horticultural crops.
5. Cultivation of ornamental plants.

## Plant Protection

1. Biological control of insect pests.
2. Cultivation of edible fungi.
3. Bio-formulation of entomogenous nematodes.
4. Varietal resistance to major diseases of sugarcane.
5. Integrated control of sugarcane soil pests.
6. Survey of movement and control of rats in sugarcane fields.
7. Control of the major diseases of lily, anthurium, and gladiolus.
8. Control of *Phalaenopsis* and turfgrass insect pests with pyroligneous acids.
9. Rapid propagation of virus-indexed gladioli.
10. Mass propagation of virus-indexed seed cuttings of Badila.

## Sugar Technology

1. Experiment on sugar refining.
2. Development of a computer control system for the clarification process.
3. Manufacturing of liquid sugar from molasses.
4. Treatment of sugar factory wastewater.
5. Treatment of waste wire with chemical reagents.

## Biotechnology

1. Selection and application of coagulative yeast for alcohol fermentation.
2. Isolation of phytase producing micro-organisms.
3. Pilot plant tests of L-lysine production.
4. Pilot plant trial of production of coupling sugar and $\beta$-CD with CGTase.
5. Production of xylo-oligosaccharide.
6. Separation and purification of fructo-oligosaccharide.
7. Development of yeast and glutathione containing beverage.
8. Development of new products from cellulosic bagasse and waste paper materials.
9. Production of 5′-nucleotides and their derivatives.

# Technical Services

## Information and Extension Center

To enhance the extension and information service efficiency at this institute, the Data Processing and Publication Center was incorporated with the Extension and Training Center this year. This center is responsible for (1) editing and publishing the Institute's publications, (2) managing and servicing of the Sugar Research Library, (3) operating and maintaining the multi-usage computer systems, (4) taking and producing photographs and slides, (5) arranging technical training programs, (6) compiling videos for extension and farmer education, and (7) strengthening cooperation between scientists of this institute and various specialists in the Taiwan sugar industry.

This center edited, published and distributed the Report of the Taiwan Sugar Research Institute, the Annual Report, the Research Abstract, and the Extension Bulletin for this year to researchers, libraries, professors, students, extension workers, and administrators in many countries.

In addition, Research in Taiwan's Sugar Industry in the Past and Future (in Chinese) was published to celebrate the 90th anniversary of this institute in July, 1992.

Under the International Technical Cooperation Program, training courses on sugarcane agronomy and diversification projects implemented by the sugar industry in Taiwan were given to eight agronomists and managers from P. T. Gunung Madu Plantations, Indonesia, in February, 1993. Also, with a memorandum of understanding between the Taiwan Sugar Corporation (TSC) and the Union of Sugar Cane and Sugar Enterprises No. 1, Vietnam (Vinasugar), a 2-month training program on the modern techniques of cane propagation and plantation management was begun for two agronomists.

## Chemical Analysis Center

In 1992–93, this center received 10,000 samples for chemical analyses. A great majority of these samples were analyzed for the diagnoses of sugar cane nutrition and soil fertility, and quality control in sugar manufacturing. A study on the replacement of lead subacetate by aluminium sulfate in pol measurements was carried out with the cooperation of the sugar mills.

## Instrument Service Center

In 1992–93, three projects were carried out. The first project was "Studies on an Automatic Control System for an Oil Boiler", and the following achievements were obtained: (1) the data files of instruments for 5 sugar mills (Pingtung, Jente, Annei, Huwei and Hualien) were built up. (2) the combustion efficiency of boilers were improved. (3) the instruments that have to be maintained or replaced were listed. The other two projects were "Development of an Automatic Control System for the Juice Clarification Process" and "Improvement of Sugar Boiling Efficiency". They were carried out in collaboration with the Department of Sugar Technology.

In addition, about 470 sets of instruments at TSRI, sugar mills, and by-product factories were inspected and maintained in good repair this year.

# Publications


Adams, R. H., C. M. Huang, F. K. Higson, V. Brenner, and D. D. Focht. 1992. Construction of a 3-chlorobiphenyl-utilizing recombinant from an intergeneric mating. Appl. Environ. Microbiol. 58:647–654.

Chang, Y. S., C. C. Lo, and K. S. Yang. 1992. Estimation of sugarcane yields by sampling methods in varietal trials. Rept. Taiwan Sugar Res. Inst. 137:15–22.

Chang, Y. S. and C. C. Lo. 1992. Analysis of performance of newly released sugarcane variety ROC 16 at regional trial. Rept. Taiwan Sugar Res. Inst. 138:1–9.

Chang, Y. S. and C. C. Lo. 1993. Genetic relationships among major sugarcane cultivars in Taiwan. Rept. Taiwan Sugar Res. Inst. 140:1–10.

Chen, C. T. and J. G. Fang. 1992. Research and control of sugarcane diseases in Taiwan. In: Research in Taiwan's Sugar Industry in the Past and Future – In Celebration of the 90th Anniversary of the Taiwan Sugar Res. Inst. – pp.185–215. (in Chinese)

Chen, W. H., R. M. Hsieh, W. T. Tsai, C. C. Wu, M. S. Chyou, T. J. Huang, J. B. Chen, F. W. Ho, S. L. Yang, G. C. Wey, and L. Yang. 1992. Achievement and development of recent research in horticulture. In: Research in Taiwan's Sugar Industry in the Past and Future – In Celebration of the 90th Anniversary of the Taiwan Sugar Res. Inst. – pp.151–183. (in Chinese)

Chen, C. H. 1992. Restropective of sugar technology research. In: Research in Taiwan's Sugar Industry in the Past and Future – In Celebration of the 90th Anniversary of the Taiwan Sugar Res. Inst. – pp.245–259. (in Chinese)

Chen, J. B., W. H. Chen, T. Tsai, C. L. Pan, G. D. Wu, and Y. C. Hung. 1993. A simple nutriculture box for growing vegetables and flowers. Taiwan Sugar 40(2):12–16. (Abstract)

Chen, Y. H., C. C. Lo, and C. Chen. 1992. Colchicine-induced amphiploids from cell culture of *Saccharum-Miscanthus* hybrids. Taiwan Sugar 39(6):17–21. (Abstract)

Chen, W. H. 1992. Application of biotechnology techniques in the improvement of *Phalaenopsis* : Transgenic technology. In: Proceedings of Seminars for the 90th Anniversary of the Taiwan Sugar Res. Inst. pp.153–160. (in Chinese)

Cheng, C. P., C. T. Chen, H. J. Su, and T. C. Deng. 1992. Monoclonal antibodies against sugarcane mosaic virus. Proceedings of the Symposium on Plant Virus and Virus-like Diseases (in press). NCHU, Taichung, Taiwan.

Cheng, W. Y. 1992. Control of sugarcane pests and wild rats in cane fields after the restoration of Taiwan to the ROC. In: Research in Taiwan's Sugar Industry in the Past and Future – In Celebration of the 90th Anniversary of the Taiwan Sugar Res. Inst. – pp.217–244. (in Chinese)

Cheng, W. Y., Z. T. Wang, T. H. Hung, and J. K. Hung. 1993. Seasonal occurrences of sugarcane woolly aphid and its predators on autumn planted canes. Rept. Taiwan Sugar Res. Inst. 139: 19–31.

Deng, T. C., I. L. Yang, and C. T. Chen. 1993. Taxonomic properties of a sourgrass isolate of maize dwarf mosaic virus in Taiwan (Research note). J. Agric. Res. China 42(1):64–73.

Hsiao, Y. C., J. C. Lin, and C. H. Jen. 1992. Development of automatic control system for crystallization process. Rept. Taiwan Sugar Res. Inst. 138:21–36.

Hsiao, Y. C., S. P. Hu, J. C. Lin, and C. H. Jen. 1993. Development of automatic control system for juice clarification process. Rept. Taiwan Sugar Res. Inst. 140:11–27.

Hsie, M. C. 1993. Isolation and selection of thermotolerant yeast with high yield of ethanol from molasses. Rept. Taiwan Sugar Res. Inst. 140:29–38.

Hsie, M. C., H. C. Chen, K. S. Tzeng, T. W. Hung, T. S. Weng, Y. T. Liu, C. I. Wang, and P. C. Huang. 1993. Industrial scale tests of fermentative production of ethanol from molasses by T-17 and Hualien strains. Rept. Taiwan Sugar Res. Inst. 140:39–46.

Hsieh, R. M., W. H. Chen, W. T. Tsai, M. S. Chyou, and C. C. Wu. 1992. Electrophoretic pattern of isozymes in *Phalaenopsis* spp. In: Proceeding of SABRAO International Symposium on Impact of Biological Research on Agricultural Productivity. Taichung, Taiwan. p.319–329.

Hsu, S. Y., A. L. Hour, and T. H. Wang. 1992. Selection strategy for sugarcane seedling Brix. Chinese Agro. Jour. 2(4):230–231. (Abstract)

Huang, S. L., Y. T. Chuang, and Y. T. Liu. 1992. Studies on the characters and stability improvement of red pigments from cactus (*Opuntia dillenni*) fruit. Rept. Taiwan Sugar Res. Inst. 138:37–45.

Huang, C. M. and W. C. Chen. 1992. Isolation and selection of bacteria for the degradation of hazardous substances. In: Proceedings of Seminars for the 90th Anniversary of the Taiwan Sugar Res. Inst. pp.153–160. (in Chinese)

Hung, J. J., W. C. Liu, C. H. Chang, J. S. Tzeng, and S. W. Li. 1992. An evaluation of buffering potential of selected Taiwan agricultural soils for acidic deposition. Rept. Taiwan Sugar Res. Inst. 138:11–19.

Li, S. W., W. C. Liu, Y. S. Sheu, R. T. Tang, L. H. Huang, M. C. Liu, Y. T. Fang, C. F. Chen, I. J. Fang, Y. Y. Chan, P. L. Wang, and C. M. Huang. 1992. Research in agronomy: a review and prospects. In: Research in Taiwan's Sugar Industry in the Past and Future – In Celebration of the 90th Anniversary of the Taiwan Sugar Res. Inst. – pp.75–150. (in Chinese)

Li, S. W. 1993. Recent fertilizer application in Taiwan sugarcane field. Taiwan Sugar 40(1):8–13. (Abstract)

Liang, Y. G., C. T. Chen, and C. S. Lee. 1992. Sugarcane diseases intercepted in quarantine in Taiwan. Taiwan Sugar 39(4):12–13. (Abstract)

Liang, Y. G. and N. J. Ko. 1992. Host range and cytology of a virus causing mild mosaic on carnation. Plant Pathology Bulletin 1:184–189.

Lin, J. C. 1992. Application of computer control in the Taiwan sugar industry. In: Proceedings of Seminars for the 90th Anniversary of the Taiwan Sugar Res. Inst. pp.161–164. (in Chinese)

Lin, J. C., C. H. Chen, R. Y. Chang, and C. H. Jen. 1992. Computer control system for syrup flotation process. Rept. Taiwan Sugar Res. Inst. 137:33–41.

Liu, W. C. 1992. The mechanisms of soil infertility and their corresponding productivity in sugarcane fields. In: Proceedings of Seminars for the 90th Anniversary of Taiwan Sugar Res. Inst. pp. 27–40.

Liu, W. C., J. J. Hung, C. H. Chang, J. S. Tzeng, and S. W. Li. 1992. Buffering mechanisms of selected Taiwan agricultural soils to acidic precipitation. Rept. Taiwan Sugar Res. Inst. 137: 23–31.

Liu, Y. T., M. C. Hsie, Y. T. Chuang, W. F. Yee, C. Y. Chang, and G. S. Wang. 1992. Studies and prospects of sugar by-products. In: Research in Taiwan's Sugar Industry in the Past and Future –

In Celebration of the 90th Anniversary of the Taiwan Sugar Res. Inst. – pp. 261–315. (in Chinese)

Liu, Y. T. 1992. Industrial fermentation of amino acids. In: Proceedings of Seminars for the 90th Anniversary of the Taiwan Sugar Res. Inst. pp. 71–111.

Liu, Y. T. 1993. The application of biotechnology in ethanol and lysine fermentation from cane molasses. Taiwan Sugar 40(3):8–16. (Abstract)

Liu, M. C. 1993. Plant regeneration in cell suspension cultures of sugarcane as affected by activated charcoal medium composition and tissue source. Taiwan Sugar 40(3):18–25. (Abstract)

Lo, C. C. 1992. Introduction, collection, conservation and utilization of sugarcane germplasm at the Taiwan Sugar Research Institute. In: Research in Taiwan's Sugar Industry in the Past and Future. – In Celebration of the 90th Anniversary of the Taiwan Sugar Res. Inst. – pp. 27–73. (in Chinese)

Lo, C. C. 1992. Retrospects and prospects of sugarcane breeding research in Taiwan. In: Research in Taiwan's Sugar Industry in the Past and Future. – In Celebration of the 90th Anniversary of the Taiwan Sugar Res. Inst. – pp. 1–25. (in Chinese)

Lo, C. C. 1992. Breeding of new sugarcane variety ROC 16. Taiwan Sugar 39(5):8–11. (Abstract)

Sheu, Y. S., P. C. Yang, and S. W. Li. 1992. Effects of soil moisture on the growth and maturity of recent sugarcane varieties in Taiwan. Taiwan Sugar 39(5):12–16. (Abstract)

Shia, B. C., T. L. Lin, and R. T. Tang. 1993. Forecasting models for the sugarcane yield in Tainan area with two-step regression to combine multiple weather factors. Rept. Taiwan Sugar Res. Inst. 139:1–17.

Tsai, C. C., C. P. Lin, and C. T. Chen. 1992. Application of monoclonal antibodies in the detection of *Xanthomonas albilineans*, the sugarcane leaf scald pathogen. Plant Pathology Bulletin 1:159–165.

Tsai, S. M. 1992. Application and prospect of an expert system in integrated management of sugarcane pests and diseases. In: Proceedings of Seminars for the 90th Anniversary of the Taiwan Sugar Res. Inst. pp. 141–151. (in Chinese)

Tsai, W. T., W. H. Chen, R. M. Hsieh, M. S. Chyou, and C. C. Wu. 1992. An important factor affecting the germination and growth of *Phalaenopsis* seeds. In: Proceeding of the SABRAO International Symposium on Impact of Biological Research on Agricultural Productivity. Taichung, Taiwan. pp. 219–228.

Wang, P. L., S. W. Li, Y. T. Chang, and T. P. Yao. 1992. Salt leaching in the stratified soil. Taiwan Sugar 39(4):8–11. (Abstract)

Wang, T. H., A. L. Hour, S. Y. Hsu, and C. C. Lo. 1992. Data base management system for sugarcane breeding program. Rept. Taiwan Sugar Res. Inst. 137:1–13.

Wang, J. S., Y. C. Kuo, W. L. Cheng, and Y. T. Liu. 1993. Production of L-lysine by *Brevibacterium* sp. P1–13 in fed-batch fermentation using molasses medium. Rept. Taiwan Sugar Res. Inst. 139:33–41.

Wang, J. S., W. C. Cheng, and Y. T. Liu. 1993. Fermentation production of L-lysine with raw sugar medium by *Brevibacterium* sp. P1–13. Rept. Taiwan Sugar Res. Inst. 139:43–53.

Weng, T. H., Y. Y. Chan, and S. W. Li. 1993. The mode of fertilizer nitrogen uptake of sugarcane. Taiwan Sugar 40(2):8–11. (Abstract)

Yin, S. A. and S. J. Yang. 1993. Intercropping potato with sugarcane in western division of Fiji. Taiwan Sugar 40(1):14–21. (Abstract)

# Appendix

## Seminars

Control and management of *Phalaenopsis* diseases. (Mr. G. C. Wey)

Properties and value of natural pesticides from the Neem Tree, *Azadirachta indica*. (Mr. P. H. Jiang)

Highlights of the gladiolus industry in Taiwan. (Mr. Y. T. Chen)

Evaluation of health food. (Dr. Y. T. Liu)

Changes in the sugarcane selection system in Taiwan. (Mr. C. T. Huang)

Research and control of sugarcane diseases in Taiwan. (Dr. C. T. Chen)

Production of sugar and sugarcane in Taiwan, in the past 10 years and in the future. (Mr. W. S. Chin)

A brief introduction to the instrument library management system. (Mr. F. M. Chen)

Plant water deficit. (Mr. Y. S. Sheu)

Biotechnology in plant protection. (Mr. C. S. Lee)

Genetic relationships and comparisons of sugar contents among sugarcane cultivars ROC 1, ROC 10 and ROC 16. (Dr. Y. S. Chang)

Self-sufficient plan of water utilization in sugar mills. (Mr. W. D. Hsieh)

The dissipation and movement of atrazine in soil. (Mr. M. C. Liu)

*Phalaenopsis* wild species and their application in breeding. (Mr. W. T. Tsai)

Gene therapy. (Mr. C. C. Chang)

Chinese windows environment as a powerful tool for research activities. (Mr. S. M. Tsai)

Evaluation of parents with data for sugarcane selection. (Miss A. L. Hour)

Improvement of the *Phalaenopsis* varieties in TSC. (Dr. W. H. Chen)

The application of supercitical fluids to extraction. (Mr. J. S. Wang)

Post harvest treatment of *Phalaenopsis* cut flower preservation and prospect. (Miss L. Yang)

Application of stable isotopes on research. (Dr. W. C. Liu)

The Friedel-Crafts acylation of benzene with $\alpha$-substituted succinic anhydrides. (Mr. H. K. Sheen)

Prediction of the commercial sugar yield. (Dr. T. H. Weng)

An introduction to the statistical graphics system. (Mr. M. H. Jean)

Control of cockroaches. (Mr. S. M. Chen)

Introduction to natural food pigments. (Miss S. L. Huang)

Application of the DNA polymerase chain reaction in plant breeding. (Mr. T. H. Wang)

Surge flow furrow irrigation with an underground pipeline system. (Mr. Y. T. Fang)

A new way to approach synthetic biodegradable polymers. (Dr. P. W. Yang)

Application of measurement technique of temperature and humidity on horticulture under cover. (Mr. T. J. Huang)

An exhibition at the 14th World Orchid Conference and Orchids World. (Mr. M. S. Chyou)
Biological treatment and utilization of pig wastes. (Dr. C. M. Huang)

## Scientists Sent Abroad for Advanced Study, Investigation, or Participation in International Symposia

| Name | Subject | Country | Date |
|---|---|---|---|
| W. F. Yee | The exploitation of non-polluting wood fiber products | Germany, Finland, Sweden, Denmark | 3 April – 23 April 1993 |
| S. L. Yang | Studies on the application of sex pheromone for the control of sugarcane wireworm | Japan | 24 May – 30 May 1993 |
| M. C. Liu | Congress on cell tissue culture | U.S.A. | 3 June – 11 June 1993 |

## Foreign Visitors

Australia

Mr. Peter Osborne; Ms. Elizabeth Sullivan; Mr. Grahame Baker; Mr. Graham Davies; Mr. David Stevenson; Mr. Peter Derrett; Mr. Philip Pascall; Ms. Romald Huang

Canada

Dr. Jason Wang

England

Dr. Derek Brewer; Dr. Dennis A. Baker

Germany

Mr. Claus Clemens; Mr. Horst Frers

India

Mr. Suresh Chaturvedi; Dr. H. N. Singh

Indonesia

Mr. R. Sutomo Menggolo; Dr. Husto Sudewo; Mr. Arifin Said; Mr. Abdul Rasjid

Japan

Mr. Matsuda Yasuo; Dr. Eizo Maeda; Mr. Sato Hajime; Mr. Masaki Shimabuku; Mr. Morio Nakasone; Mr. Masahiko Taira; Mr. Katsuhiko Higa; Mr. Katsu Yoshi Miyagi; Mr. Kokichi Nikadori; Mr. Tomonori Ooshiro; Mr. Manryo Hasegawa; Mr. Akiyoshi Hiraoka; Mr. Yoshio Yogi; Mr. A. Yamashiro; Mr. S. Atarima

The Netherlands

Dr. H. Stigtor; Dr. J. Nijkamp; Dr. K. Van Dam

Philippines

Mr. Juanito R. Remulla; Mr. Felicisimo T. Sanluis; Mr. Vicente A. Mayo; Mr. Casimiro M. Ynares, Jr.; Mr. Roberto P. Racelis; Mr. Tomas I. Alcantara; Mr. Tagumpay R. Jardiniano; Dr. Richard A. I. Osmond; Mr. Manuel R. Tayas; Mr. Teodoro C. Tiongson; Mr. Raul S. Martinez; Mr. Felix K. Limcaoco; Mr. Jesus A. Liganor; Mr. Miguel K. Lorza; Mr. Manuel J. Colayco, Jr.; Mr. Manolo M. Quiray; Mr. Jose Manuel Lopa; Mr. Herman Gregorio

South Africa

Dr. Karl Nuss; Dr. James Blose; Dr. Bevin Worlock

U.S.A.

Mr. U. C. Upadhiaya; Dr. Jerry S. Walker

Vietnam

Mr. Vu Tuyen Hoang; Mr. Nghiem Chung Lan; Mr. Nguyen Thanh Van; Mr. Ngyuen Khang; Mr. Nguyen Huu Bao; Mr. Dang Minh Tan; Mr. Le Van Tam

# Personnel

Director: C. C. WANG, Ph. D.
Associate Director: L. H. WANG, Ph. D.
Advisor to TSC: C. C. LO, M. S.
Special Assistant to Director: Y. C. MA, B. S.
Executive Secretary: R. S. CHEN, B. S.

### Department of Plant Breeding

Y. S. CHANG, Ph. D., Plant Breeder, Dept. Head
M. C. LIU, Ph. D., Plant Breeder
S. Y. HSU, Ph. D., Plant Breeder
C. T. HUANG, B. S., Plant Breeder
Y. T. CHEN, B. S., Associate Plant Breeder
C. Y. MENG, B. S., Associate Plant Breeder
K. S. YANG, B. S., Assistant Plant Breeder
K. R. WANG, B. S., Assistant Plant Breeder
Y. H. CHEN, Ph. D., Assistant Plant Breeder
T. H. WANG, M. S., Assistant Plant Breeder
A. L. HOUR, M. S., Assistant Plant Breeder
S. T. LIN, Assistant Plant Breeder

### Department of Agronomy

S. W. LI, Ph. D., Soil Chemist, Dept. Head
Y. Y. CHAN, B. S., Soil Scientist
W. C. LIU, Ph. D., Soil Chemist
Y. T. FANG, B. S., Civil Engineer
C. M. HUANG, Ph. D., Associate Soil Microbiologist
P. L. WANG, B. S., Associate Agricultural Engineer
L. KONG, B. S., Associate Plant Physiologist
R. T. TANG, M. S., Associate Agricultural Meteorologist
L. H. HUANG, B. S., Associate Agricultural Engineer
I. J. FANG, Associate Soil Scientist
S. A. YIN, M. S., Associate Agronomist
C. F. CHEN, Associate Civil Engineer
Y. S. SHEU, M. S., Associate Soil Physicist
T. H. WENG, Ph. D., Associate Soil Scientist
M. C. LIU, M. S., Assistant Agronomist
J. S. TZENG, M. S., Assistant Plant Physiologist
C. S. TSAI, M. S., Assistant Soil Scientist
K. Y. JIANG, B. S., Assistant Agronomist

### Department of Horticulture

W. H. CHEN, Ph. D., Plant Biotechnologist, Dept. Head
T. J. HUANG, B. S., Agricultural Engineer
M. S. CHYOU, B. S., Associate Civil Engineer
J. B. CHEN, B. S., Associate Agronomist
F. W. HO, Associate Agronomist
C. C. WU, B. S., Associate Agricultural Engineer
G. D. WU, B. S., Associate Agronomist
G. C. WEY, M. S., Assistant Plant Pathologist
R. M. HSIEH, M. S., Assistant Plant Breeder
C. L. PAN, Assistant Agricultural Engineer

L. YANG, M. S., Assistant Plant Physiologist
W. T. TSAI, M. S., Assistant Plant Breeder
Y. M. FU, M. S., Assistant Biotechnologist
M. H. JEAN, M. S., Assistant Agricultural Engineer

### Department of Plant Protection

W. Y. CHENG, M. S., Entomologist, Dept. Head
C. T. CHEN, Ph. D., Plant Pathologist
C. S. LEE, M. S., Plant Pathologist
S. L. YANG, M. S., Entomologist
Z. N. WANG, M. S., Associate Plant Pathologist
P. Y. WANG, B. S., Associate Entomologist
J. G. FANG, Ph. D., Associate Plant Pathologist
C. H. CHANG, B. S., Associate Entomologist
S. M. TSAI, M. S., Assistant Entomologist
S. M. CHEN, M. S., Assistant Entomologist
Y. G. LIANG, M. S., Assistant Plant Pathologist

### Department of Sugar Technology

C. H. CHEN, M. S., Chemical Engineer, Dept. Head
J. S. WU, Associate Mechanical Engineer
C. S. TING, M. S., Assistant Chemist
T. P. HSIEH, Assistant Chemical Engineer
R. Y. CHANG, Assistant Chemical Engineer
W. F. LIN, B. S., Assistant Chemical Engineer
Y. C. HSIAO, M. S., Assistant Chemical Engineer
F. Y. LIU, M. S., Assistant Chemical Engineer
J. C. LIN, M. S., Assistant Chemical Engineer
W. D. HSIEH, M. S., Assistant Chemical Engineer
H. K. SHEEN, M. S., Assistant Chemical Engineer
S. P. HU, Assistant Mechanical Engineer

### Department of Biotechnology

Y. T. LIU, Ph. D., Microbiologist, Dept. Head
M. C. HSIE, M. S., Microbiologist
Y. T. CHUANG, B. S., Microbiologist
W. F. YEE, B. S., Chemical Engineer
Y. C. KUO, Associate Chemical Engineer
S. L. CHENG, B. S., Associate Chemist
P. W. YANG, Ph. D., Associate Chemical Engineer
C. Y. CHANG, M. S., Assistant Chemical Engineer
G. S. WANG, Ph. D., Assistant Chemist
S. L. HUANG, B. S., Assistant Chemist
J. S. WANG, M. S., Assistant Chemical Engineer
W. L. CHENG, M. S., Assistant Microbiologist
P. L. CHEN, M. S., Assistant Microbiologist
Y. Y. CHENG, M. S., Assistant Chemical Engineer
C. C. CHANG, M. S., Assistant Microbiologist

### Data Processing and Publication Center

S. H. YANG, B. S., Extension Specialist, Superintendent
M. S. LIU, B. S., Associate Editor
H. C. HUANG, B. S., Associate Editor
T. H. CHAO, B. S., Associate Electronic Engineer
C. J. LIN, B. S., Assistant Programmer
Y. C. WANG, Assistant Editor

### Extension and Training Center

S. H. YANG, B. S., Extension Specialist, Superintendent
C. S. TOU, B. S., Associate Extension Specialist
K. S. CHEN, B. S., Associate Extension Specialist
H. M. CHANG, B. S., Assistant Chemist

### Instrument Services Center

Y. C. WANG, B. S., Mechanical Engineer, Superintendent
C. H. JEN, Associate Electronic Engineer
H. C. YANG, Assistant System Engineer
M. D. HUANG, B. S., Assistant System Engineer
F. M. CHEN, Assistant System Engineer

### Chemical Analysis Center

C. S. YEH, B. S., Chemist, Superintendent
J. S. CHEN, Associate Chemist
H. I. SHIUE, B. S., Associate Chemist
W. S. CHEN, B. S., Assistant Chemist
M. T. LEE, Assistant Chemist
W. S. TSENG, Assistant Chemist
M. C. HUNG, Assistant Chemist

### Farm Management Center

S. K. LIN, B. S., Agronomist, Superintendent
S. C. TING, Associate Veterinarian
C. Y. HUANG, B. S., Assistant Agronomist
P. C. WANG, Assistant Agronomist

### Hsinying Sugarcane Experiment Station

C. C. WEI, B. S., Agronomist, Superintendent
C. M. HUANG, B. S., Associate Agronomist
C. S. DOU, B. S., Associate Agronomist
C. H. JUAN, B. S., Associate Entomologist
W. S. CHIN, B. S., Assistant Agronomist
C. W. YANG, Associate Extension Specialist
K. Y. CHANG, B. S., Associate Agronomist
C. B. JUANG, B. S., Assistant Agronomist

J. M. CHEN, M. S., Assistant Agronomist
B. L. LO, Assistant Agronomist

## Pingtung Sugarcane Experiment Station

F. Y. HSIA, B. S., Agronomist, Superintendent
S. J. CHANG, B. S., Associate Agronomist
P. H. JIANG, B. S., Associate Entomologist
S. Y. CHUNG, B. S., Associate Agronomist
S. L. LIAO, B. S., Associate Extension Specialist

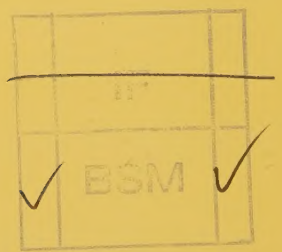
## Management

M. H. YANG, Chief of General Affairs Office
F. Q. CHEN, Chief of Personnel Office
C. S. CHUNG, B. S., Chief of Accounting Office
S. K. LIN, B. S., Chief of Industrial Safety and Hygiene Office

TAIWAN SUGAR RESEARCH INSTITUTE
EDITORIAL BOARD

**Editor-in-Chief**

C. C. Wang

**Editors**

Y. S. Chang
C. H. Chen
W. H. Chen
W. Y. Cheng
S. W. Li
Y. T. Liu
C. C. Lo
L. H. Wang
S. H. Yang